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Explanatory Note.

Illustrated articles are marked with an asterisk (*). Book notices are denoted by a dagger (†). The cross references condense the matter and assist the reader, but are not to be regarded as complete or conclusive. So, if there were a reference from "Boiler" to "Furnace" and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross reference. A reference from "Oil" to "Lubricant" would apply equally to "Lubrication," "Lubricator," etc. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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POWER

Vol. 37 NEW YORK, JANUARY 7, 1913 No. 1

The Eternal Question

(With Apologies to C. D. Gibson)

Suggested by Charles M. Young, Philadelphia, Penn.

The Prudential Insurance Co. Plant

By Charles H. Bromley

SYNOPSIS—The power equipment for a great group of office buildings is fully described. This plant is particularly interesting for the completeness of its equipment and its remarkable growth.

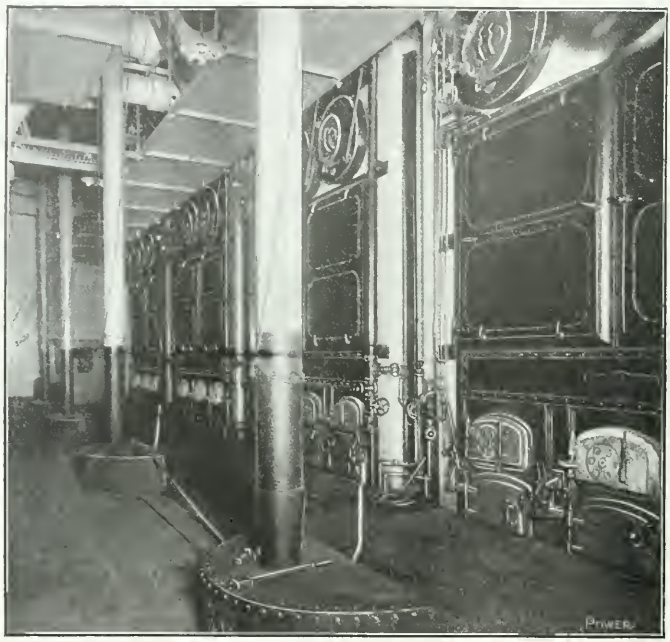


Fig. 1. Boiler Room. New Section

The Prudential Insurance Co.'s plant, at Newark, N. J., which supplies power to the company's group of office buildings, is remarkable for its growth. Twenty years ago the plant's capacity was about 50 hp.; today it is 5000, of which 1500 is electrically devoted. Few office-building plants attain so rapid a growth.

In 1902, the "old plant" was completed and subsequently in 1911, the "new plant" was installed to furnish power to additional buildings, provision being made for future increased demand.

The plant occupies most of the block bounded by Broad, Academy, Bank and Halsey Sts.; the engine rooms are entirely visible from the streets. The boiler room is in two sections and is on the street level. It is spacious, admirably ventilated and lighted, as the skylights are large, and the walls are finished in white-enameled brick.

There are 12 water-tube boilers, eight of which are of 250 hp. each and are in the old section, while the remaining four are of 550 hp. each, and are in the new section. Those in the old section are of the two-drum type, while those in the new section are of the three-drum type. They are supplied with forced-draft from two engine-driven fan blowers of 10-ft. diameter in the cellar under the boilers with the air intake on top of the boilers to obtain the heated air and force it under the grates.

No. 1 buckwheat coal is burned, and supplied by gravity to semi-circular boxes in front of the boilers through extra heavy chutes from bins of 600 tons capacity each, above the boiler room. The chutes in the new section extend vertically to avoid the excessive wear experienced with the inclined ones in the old section. The coal first passes through automatic weighing and registering machines under the sidewalk at the head of each belt conveyor, which carries it into the cellar where it is dumped into bucket conveyors that raise it to the overhead bins. The ashes are dropped from hoppers under the grates directly into these conveyors and carried by them to trippers, which dump them into chutes leading to ash chambers over each driveway in each boiler room from which they may be loaded directly into wagons. A view of the new boiler room, showing the vertical coal chutes, may be seen in Fig. 1.

After the new boilers were installed and carrying the entire load, the grate area of the old ones was enlarged

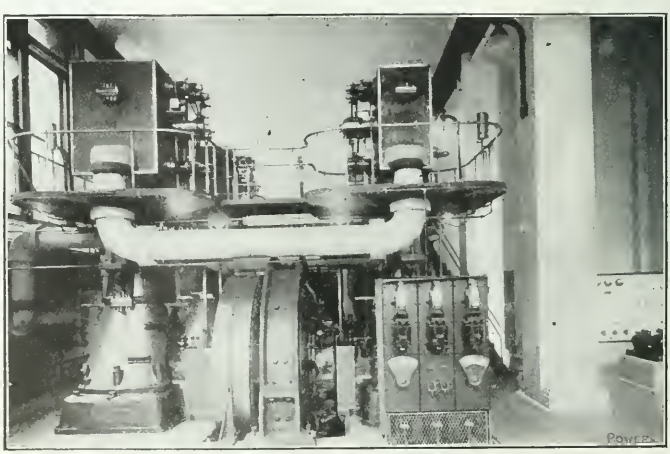


Fig. 2 New 750-hp. Units and Contactor Panel

by placing the bridgewall back 2 ft., thus giving the grates a depth of 9 instead of 7 ft. The average daily coal consumption is 50 tons. The CO_2 production averages 15 per cent. This serves to indicate the thoroughness of the boiler-room equipment and the excellency of firing. Damper regulators, draft gages and a recording pyrometer are also provided.

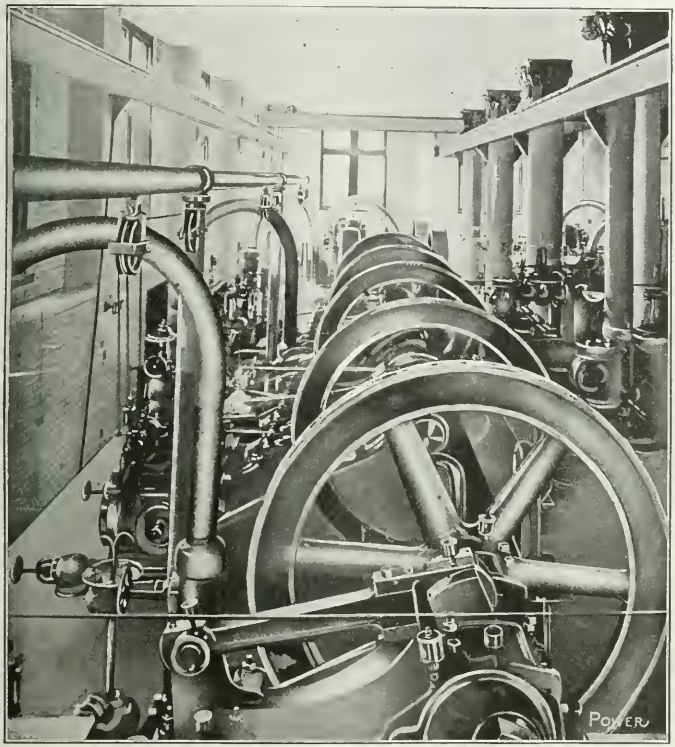


FIG. 4. OLD ENGINE ROOM, ELEVATOR PUMPS IN FOREGROUND; GENERATING UNITS IN REAR

Steam at 150 lb. is led to headers, the piping of which is so arranged that any number of boilers in either section may be cut in or out of service without interruption of the steam supply. Non-return stop valves are in all lines from the boilers to the headers. A separate steam line is run to one of the 250-hp. engines so that ordinary steam main troubles will cause no interruption of the electric service. The same is true of lines to the feed pumps and injectors. Uninterrupted service is the chief consideration in this plant. City water is filtered and heated by exhaust steam to 212 deg. F., before going into the boilers, as shown by a recording thermometer, the temperature being automatically controlled by a compressed-air-operated thermostat controlling the admission of steam to the heater. The feed pumps, located in the cellar, are of the duplex vertical type.

ENGINES AND GENERATORS

There are two engine rooms, one floor below the street level, but with ceilings rising to the floor above this level. The old engine room fronts on Bank and Halsey Sts., and the new one on Academy and Halsey. They are separated by the boiler room and refrigeration plant through which leads a passageway connecting them on the same level. This passageway greatly facilitates communication to and from each engine room.

Previous to the new three-wire system installation, 120-volt generators were used on a two-wire system. These were displaced by 240-volt generators, which are used throughout; all are directly connected to their engines.

The change-over from the 120-volt, two-wire system to the 240-volt, three-wire system was made without an interruption of service. It must be remembered that the wiring throughout all the buildings had to be likewise changed and this was also done without interrupting the service. All of this required installing temporary switchboards, panel boxes, circuits, etc.

In the old engine room are three 250-hp. and one 175-hp. horizontal tandem-compound four-valve noncondensing engines each directly connected to 240- and 150-kw. generators respectively.

The two units in the new engine room are of the vertical cross-compound type, and of 750 hp. each, di-

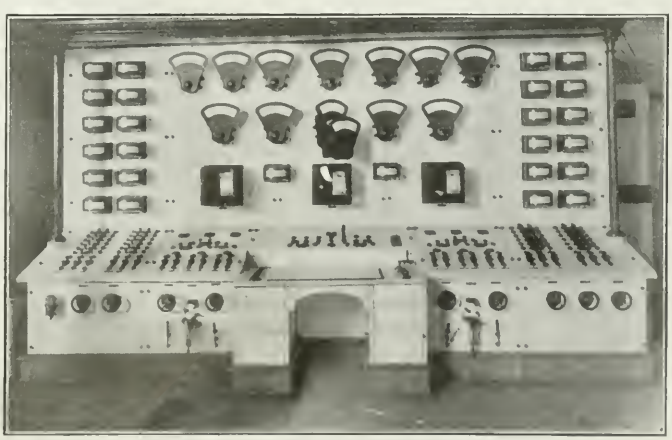


FIG. 3. MAIN SWITCHBOARD, REMOTE-CONTROL TYPE

rectly connected to 500-kw. generators. The foundation for another of these large units is provided alongside the present ones. All units are noncondensing. The new engine room and the new units are shown in Fig. 2.

Switchboard

The switchboard (Fig. 3) is of the remote-control type, reflector, which throws light over the entire board. Space would not admit of placing the contactor board in the engine room, so it was located in a small room in the cellar, as nearly central to the generators and point of distribution to the sub-switchboards as possible. Connection of the generator leads could not be made in the generator pits, so contractor panels, each having a volt-

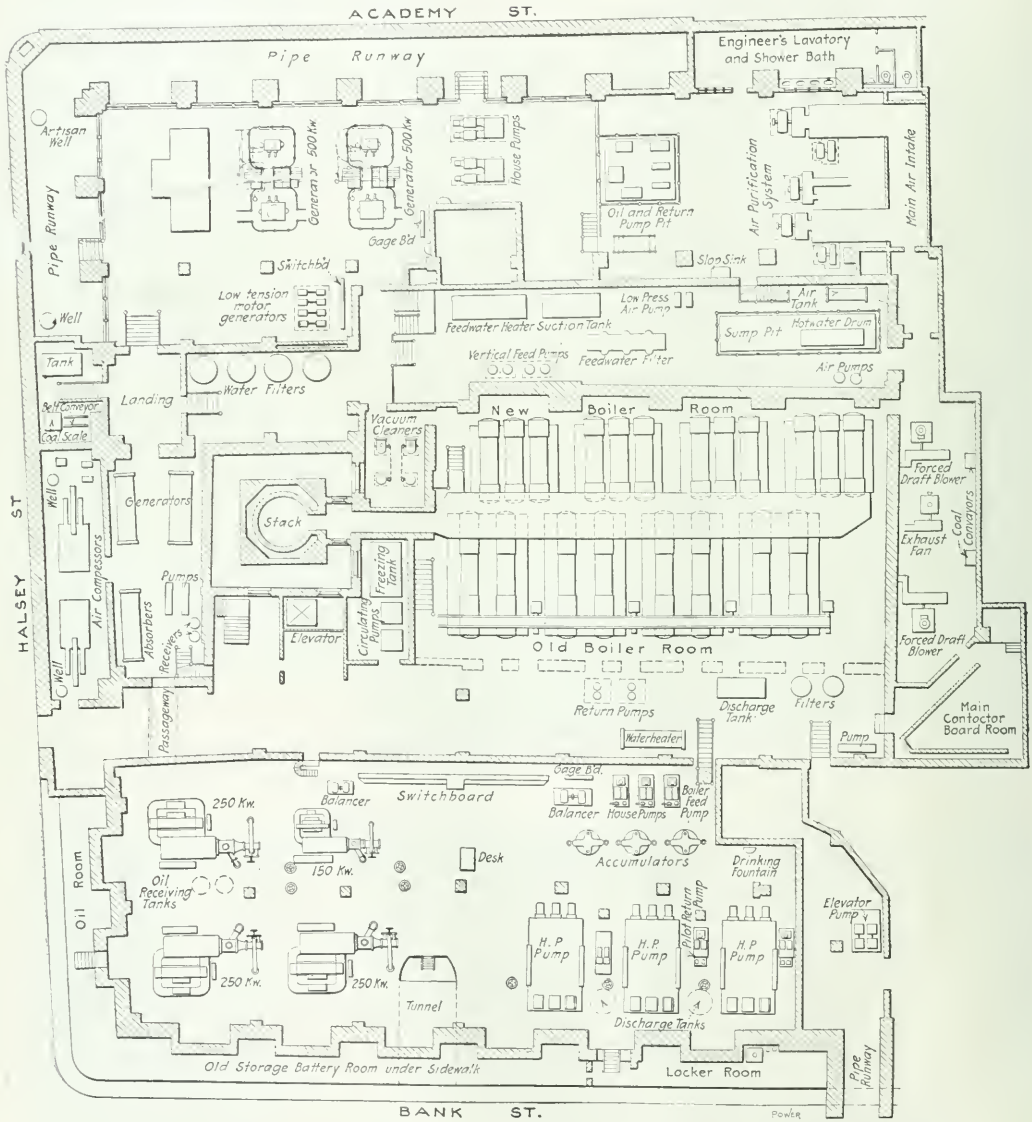


Fig. 5. Diagram of Prudential Insurance Co.'s Plant, Showing Location of Equipment

located in the old engine room, and is considered the finest of its kind in the world. An impressive decorative feature of the board is the two art bronze columns at each end supporting the head work and the mottled glass meter, ammeter, positive, negative and equalizer solenoid-operated switches controlled by pull switches on the main control board were installed. These pull switches have both electric and mechanical signals to show whether the

circuits are open or closed. Two balancer sets capable of caring for an unbalance of 800 amp. establish the neutral leg. The busbars of the generator panels connect to large main busbars that are run under the old boiler room and there connect with the busbar leads from the generators in the old engine room.

Telephones and a push-button signal system permit code signaling from and to both engine rooms. A gong on the control board operated through a relay on the generator contactor panels continues to ring when a circuits opens until stopped by the operator. The affected circuit is also indicated by signal lamps. As it is most important that the plant and cellars be not in darkness, plug-switch receptacles connected to lines from the generator panels are provided. If a generator circuit is opened, the plugs may be inserted in any pair of terminals, thus connecting the lamp circuits back of all circuit-breakers.

Motor-generator sets furnish current at 24 volts for all annunciator, clock and signal service, no battery being used. The sets and low-tension switchboard are shown at the right in Fig. 2. The low-tension system complete is said to be the most elaborate ever installed. This is due to the size and number of buildings.

and three hoists which operate under 750 lb. with a suction pressure of 75 lb. There are seven electric elevators in the Broad St. end of the north building, four of which are of the high-speed traction type and three of the drum type. There are also eight electric dumb waiters.

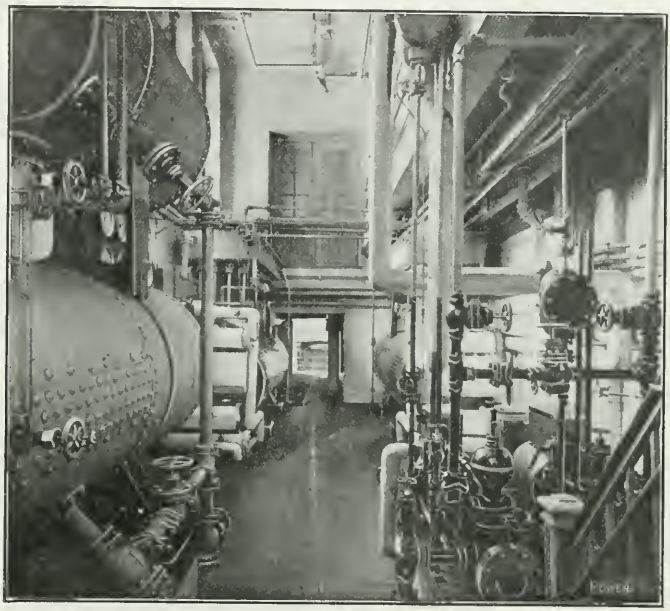


Fig. 6. Refrigeration Plant. Absorbers in Foreground

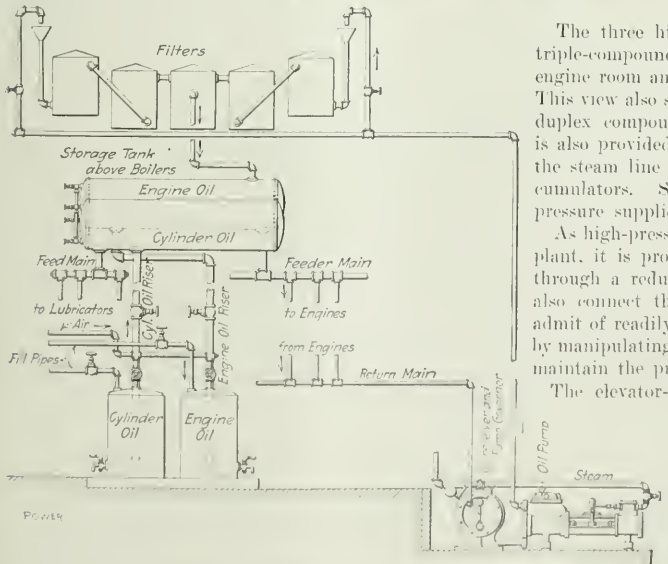


Fig. 7. Complete Oil System in the Prudential Plant

The three high-pressure elevator pumps are of the triple-compound flywheel type. These are in the old engine room and are shown in the foreground of Fig. 4. This view also shows the old generating units. A smaller duplex compound pump for night and Sunday service is also provided. All pumps are controlled by valves in the steam line operated by cables actuated from the accumulators. Special safe-lifts operate under 2500 lb. pressure supplied by a special pump.

As high-pressure (150-lb.) water service obtains in the plant, it is proposed to connect a high-pressure line through a reducing valve to the pilot-water system and also connect this system with the sewer. This would admit of readily cleaning this part of the elevator system by manipulating a few valves, as the reducing valve would maintain the pressure while the pumps were idle.

The elevator-shaft doors are each electrically locked by a device controlled through contacts made by the movement of the car. This prevents accident, as no door can be opened until the car is at that door. All cars have meters that register the travel in miles. This admits of accurately determining by reference to record the wearing qualities of the cables, etc.

A diagram of the entire plant showing the location of the machinery, artesian wells, tunnel, lavatories, etc., is given in Fig. 5.

Elevator Equipment

There are 36 high-speed, high-geared, plunger passenger elevators, two of the direct-acting plunger type

Refrigeration Plant

Two 35-ton absorption plants connected in multiple, cool all drinking water used throughout the buildings to 40 deg. F. The generators are operated entirely by exhaust steam. Motor-driven centrifugal pumps furnish condensing water and motor-driven triplex pumps circulate the cooled water through the various lines. The generators, absorbers, condensers and ammonia circulating pumps are shown in Fig. 6.

Two engine-driven air compressors are in the refrigeration plant, furnishing air at 75 lb. for lifting water from four driven wells, which supply 300,000 gal. daily. City water was formerly used for house purposes, but well water is now used, which has effected a saving of many thousand dollars in the cost of water. Due to its constant low temperature this water is excellent for use in the condensers of the refrigeration plant. The cost of operating the refrigeration plant is chiefly that incurred by pumping, as the exhaust for operating it is most plentiful when the demand on the plant is greatest, i.e., in the summer. The condenser-water circulating pumps are of the motor-driven volute type, while the drinking-water circulating pumps are of the motor-driven triplex bronze-plunger type. The house-water pressure is 80 lb., which is that due to the head of water from a tank in the North building tower. The tower is beautifully decorated with lamps and at night is the most imposing feature of Newark's illumination.

Oil Storage and Distribution System

On account of the scattered location of the various engines, pumps, etc., the distribution of oil to them was

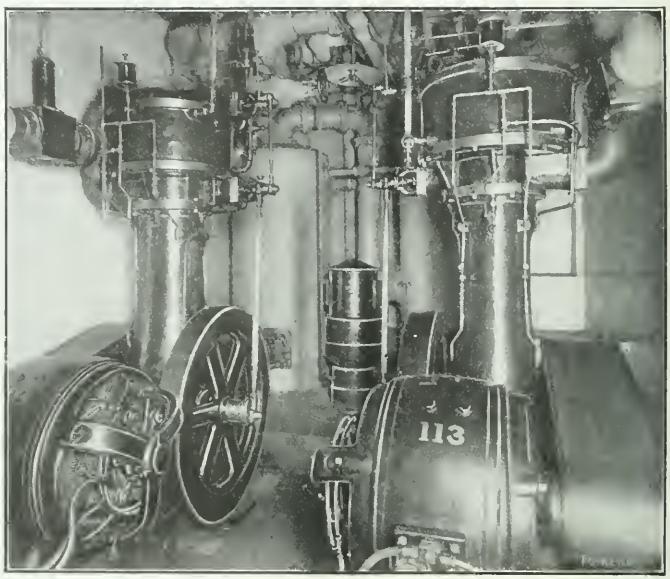


Fig. 8. Vacuum Cleaners in New North Building

REAL ESTATE DEPARTMENT

The Prudential Insurance Company of America

ENGINEER'S DAILY REPORT

For the Watch from ____ M. to ____ M., ____, 19__

ENGINE NO. | STARTED | STOPPED | HOURS RUN | BOILER NOS. | CUT IN | CUT OUT | DATE OF LAST CLEANING | ELEVATOR PUMP NO. | STARTED | STOPPED | HOURS RUN | REVOLUTION COUNTER READING | BOOST PUMP NO. | STARTED | STOPPED | HOURS RUN | TRAVEL OF PISTON IN FEET WATER NO. 1 | TRAVEL OF PISTON IN FEET WATER NO. 2 | FEED PUMP NO. | STARTED | STOPPED | HOURS RUN | TRAVEL OF PISTON IN FEET WATER NO. 1 | TRAVEL OF PISTON IN FEET WATER NO. 2 | ICE WATER PUMP NO. | STARTED | STOPPED | HOURS RUN | REVOLUTION COUNTER READING | AIR PUMP NO. | STARTED | STOPPED | HOURS RUN | REVOLUTION COUNTER READING | AIR COMPRESSORS | STARTED | STOPPED | HOURS RUN | REVOLUTION COUNTER READING

BALANCER NO. | STARTED | STOPPED | LOSS IN AMPERES | TIME | VOLTS | SWITCHBOARD READINGS: AMPERES OF BUILDINGS — PROVIDENT | MAIN | NORTH | WEST | N. WEST LIGHT | N. WEST POWER | TOTAL | VOLTS | GROUNDS — LOCATION | CLEARED | ICE MACHINE NO. | STARTED | STOPPED | HOURS RUN | REFRIGERATION: TEMPERATURES — WATER: OUTGOING | RETURN | FRESH SUPPLY | WELLS | BRINE: OUTGOING | RETURN | PRESSURES: ATMOSPHERE | GENERATOR: STEAM | AMMONIA | ABSORBER | WATER | HEATING: LIVE: ON | OFF | EXHAUST: ON | OFF

SUPPLIES: COAL | WASTE: WHITE | COLORED | LBS. | PACKING: X KO | ENGINE | COLUMBIA | PERFECTION | OILS: LARD | SPECIAL | GREASE | WATER METERS: READINGS: HOUSE SUPPLY | DRINKING WATER | PRESENT | PREVIOUS | CONSUMPTION

MEN ON DUTY IN ENGINE-ROOM

MEN ON DUTY IN BOILER-ROOM

PUMP DISPLACEMENTS | GALLONS | CUBIC FEET | SUCTION PRESSURE LBS. | DISCHARGE PRESSURE, LBS.

ELEVATOR-PUMPS NOS. 1, 2 AND 5, PER REVOLUTION ____ 0.77 0.103 20 750

" NO. 4, " ____ 2.511 0.340 20 750

ICE-WATER PUMPS, " ____ 2.04 0.273 120

BRINE-PUMPS " ____ 4.305 0.348

HOUSE-PUMPS NOS. 1 AND 3, PER FOOT OF PISTON TRAVEL ____ 2.302 0.308 80

" NOS. 2 AND 4, " ____ 4.142 0.549 80

BOILER-FEED PUMPS " ____ 0.953 0.800 160

SWITCHBOARD AND ICE MACHINE READINGS TAKEN HOURLY.

ALL OTHER RECORDS TAKEN ONE-HALF HOUR BEFORE END OF WATCH.

REMARKS

ENGINEER

Fig. 9. Fac-simile of Engineer's Daily Report Sheet

a problem best overcome by the oil-storage and distribution system, designed especially for the plant by its chief and assistant chief engineers, who also designed the oil filters, which will handle two barrels an hour. The filters, shown at the top of Fig. 7, have run over a year without cleaning and the oil leaving them now is perfectly clean. There are two sets of filters so piped as to allow of quickly changing over if one should overflow. This, however, has never happened, owing chiefly to the ample head at the filter inlet.

The oil is handled as follows:

In barrels it is dropped from the street to the "oil room" by a sidewalk lift. From the barrels it gravitates through fill pipes to receiving tanks in the cellar, as shown in Fig. 7. When the barrel is empty the valve in the fill pipe is closed, compressed air at 40-lb. pressure is then admitted to the tank, the valve in the riser to the storage tanks over the boilers is then opened and the oil forced to them. The compressed air is taken from the receiver supplying the deep-well water air-lift system. The receiver pressure is 75 lb., but is stepped down to 40 lb. by a reducing valve before being used in the oil tanks. When the oil-receiver tank is emptied the valve in the riser is closed and the air pressure cut off. The oil then gravitates through the feeder mains to the engines. Thence it runs to a receiver and small duplex pump in a pit and continues to the filters over the storage tanks, the oil runing by gravity to the storage tanks from the filters. The cylinder oil gravitates to all lubricators and oil fountains throughout the plant. The system works admirably, the only trouble encountered being the plugging of the valves of the "dirty oil" pump with waste which gradually accumulates. This is obviated by cleaning the pump chambers frequently. All machines (except a few pumps) requiring internal lubrication have force-feed lubricators.

Drips and Drains

The drainage or sanitary sewage is mostly below the sewer, so it is run into a receiver in a sump below the lowest drain level. From the receiver it flows to an ejector, which discharges it to the sewer. The ejector has a float, raised and lowered by the level of the liquid within it, which operates a valve in a compressed-air line when the ejector is full and allows the air to enter and force the liquid to the sewer. The ejector-inlet pipe has a check valve to prevent the liquid from running out when discharge occurs. A check valve in the discharge pipe prevents any inflow from the sewer. The above applies to the "new plant" only. In the "old plant" the drainage collects in pits from which it is pumped to the sewer automatically.

The drips from the steam headers, mains and all piping in the "new plant" are trapped and collected in a receiver below the traps. They are then carried to a discharge chamber at the top of the boiler house and from there are discharged into the boilers. The drips in the old plant are trapped and discharged into the feed-water heater.

Vacuum Cleaners

The vacuum-cleaning plant is divided into two sections, one in the basement of the Main building, the other in the basement of the new North building. At present the one in the Main building takes care of the Main, Prudential and West buildings, while the other two machines furnish vacuum for the North and New North buildings. Only those in the North building are shown in Fig. 5.

The machines are motor-driven, as shown in Fig. 8, which illustrates the North building machines. The vacuum lines are piped throughout the entire buildings, including the boiler and engine rooms. The tops of the boilers and headers are cleaned by vacuum.

Machine Shop

There is a complete machine shop for doing repair work and making new parts for worn machines. This shop is a necessity as outside of the many repairs to, and new parts to be made for the equipment, there is much work to be done and renewals needed by the kitchens and printing establishment. The latter occupies nearly all of the West building. The four lower floors are crowded with printing machinery, the minor repairs to which are in charge of the chief engineer.

The shop equipment consists of three quick-change lathes, one 26-in. swing, 18-ft. centers, and two 16-in. swing and 14-ft. centers; four vertical and one radial drill presses, two shapers, two emery wheels, two power hacksaws and two grindstones. All except the grindstones are driven by direct-connected individual motors.

Records and Data

Fig. 9 shows the engineers' daily report sheet. One of these is made out for each of the three watches. The report sheet is very complete and yet is not burdened with useless items. There is also a weekly report sheet, filled out by the foreman of the elevator repairmen. This report includes the headings: *Location,* under which is recorded location, number, and kind of each car, *Dumbwaiter* and *Hoist, Cylinders and Plunger, Sheaves, Operating Valves, Car and Safeties, Cables, Counter Readings* and *Supplies Used and Wanted.* At the bottom of the sheet space is left for reporting the condition of, and the repairs to, each of the nine accumulators.

A card system is kept on which is recorded all data relative to each of the great many motors throughout the buildings, the kind of service performed, size, number; size, number and kind of brushes, kinds of repairs and renewals and dates made are all recorded on these cards, one of which is made out for each motor. The purpose of these cards is to facilitate the ordering of parts.

Besides the various filled-in report sheets are the charts from the recording instruments, which are provided wherever needed. The records, therefore, are exceedingly complete.

Labor and Watches

Including the electrical division of the engineering department, there are forty employees under the direct supervision of the chief and assistant chief engineers and a chief electrician. Each of the three watch engineers has an assistant engineer on watch with him. Each man has a particular part of the equipment assigned to him. The direction of the detail work for the whole plant, exclusive of the electric lighting, is in charge of the assistant chief engineer.

The watch engineers, their assistants, oilers, switchboard tenders and firemen work in 8-hr. watches, shif -

ing about every two weeks. The switchboard-tenders are in charge of the dynamo-tender, who is responsible for all motors and generators. The other men, including steam fitters, plumbers, pumpmen, cleaners, etc., work 9-hr. all-day watches, each man taking his turn at Sunday work.

PRINCIPAL EQUIPMENT OF THE PRUDENTIAL INSURANCE COMPANY'S PLANT

No.	Equipment	Type	Use	Kw.	Volts	Amp.	R.p.m.	Size	Pres.	Hp.	Manufacturers.
8	Boilers	Water-Tube	Steam Generation						160	250	Babcock & Wilcox Co.
4	Boilers	Water-Tube	Steam Generation						160	500	Babcock & Wilcox Co.
3	Engines	Tandem-Compound	Main Unit					17x30x18 in.	160	325	Ball & Wood Engine Co.
2	Engines	Vertical Cross-Compound	Main Unit					21x35x30 in.	160	750	Ball & Wood Engine Co.
1	Engine	Tandem-Compound	Main Unit					12x22x16 in.	160	175	Ball & Wood Engine Co.
3	Generators	Direct Current	Main Unit	250	240	1000	175				Sprague Elecgric Co.
2	Generators	Direct Current	Main Unit	500	240	2000	150				Sprague Electric Co.
1	Generator	Direct Current	Main Unit	150	240	600	225				Sprague Electric Co.
1	Balancer	Direct Current	Load Balance	50	125	400	925				Sprague Electric Co.
1	Balancer	Direct Current	Load Balance	30	125	240	925				Sprague Electric Co.
1	Switchboard	Remote Control	Electrical Control								General Electric Co.
1	Switchboard	Remote Controlled	Main Contactor Board								General Electric Co.
4	Motor-Generators	Direct Current	Low Tension Electric System		20	30	1200				Holtzer-Cabot Co.
3	Flywheel Pumping Engines	Triplex-Compound Corliss	High-Pres. Elevator System					15x18x18x4¼x24 in	750		Laidlow-Dunn-Gordon Co.
1	Pump	Duplex Compound	High-Pres. Elevator System					12x18½x4x12 in.	750		Laidlow-Dunn-Gordon Co.
2	Pumps	Duplex Compound	Pilot Pres. Elevator System					5¼x7½x6x10 in.	80		Laidlow-Dunn-Gordon Co.
1	Pump	Duplex	Safe-Lift					9x2¼x10 in.	2500		Laidlow-Dunn-Gordon Co.
2	Air Compressors	Single-Stage	Compressed Air Supply				Variable	12x20x12 in.	75		Ingersoll-Rand Co.
2	Pumps	Direct Acting	Ammonia Circulation								Foster
2	Pumps	Double-Acting Triplex	Brine Circulation					5½x8 in.			Dean Bros. Steam Pump Works.
2	Pumps	Single-Acting Triplex	Icewater Circulation					5x8 in.			Dean Bros. Steam Pump Works.
2	Pumps	Duplex	Ammonia-Return					6x6 in.			H.R.Worthington Co.
2	Generators	Steam Heated	Refrigeration Plant					35 tons			Carbondale Machine Co.
2	Absorbers		Refrigeration Plant					35 tons			Carbondale Machine Co.
2	Condensers		Refrigeration Plant								Carbondale Machine Co.
1	Heater	Open	Feedwater Heater								Standard Steam Specialty Co.
2	Pumps	Vertical-Duplex Compound	Boiler Feed					12x17x15 in.			H. R. Worthington Co.
2	Pumps	Duplex-Compound	House Water Supply					9x4x15 in.	80		H. R. Worthington Co.
2	Pumps	Duplex	House Water Supply					10x10 in.	80		Laidlow-Dunn-Gordon Co.
4	Pumps	Duplex	Oiling System					3x3 in.			H. R. Worthington Co.
6	Filters		City Water Filtration								Continental Jewel Filteration Co.
2	Filters		Icewater Filtration								Continental Jewel Filteration Co.
1	Condensate Return System	Gravity Holly Loop	Drip Return to Boilers								Westinghouse-Church Kerr Co.
5	Ejectors	Compressed Air	Waste Water Lift to Sewer								Shone Co.
2	Engines	Slide-Valve	Forced Draft Fans								B. F. Sturdevant Co.
2	Coal Conveyors	Bucket	Coal Transportation								Old—McCorbin Co. New—Campbell Co.
2	Coal Conveyors	Belt	Coal Transportation								Old—McCorbin Co. New—Campbell Co.
2	Coal Weighers	Balance	Weighing Coal								Richardson Auto. Scale Co.
2	Vacuum Cleaners	Pump-12 Sweepers	Vacuum Cleaning								Vacuum Cleaner Co.
1	Vacuum Cleaner	Pump-25 Sweepers	Vacuum Cleaning								Kenney Co.

As shown in the diagram, Fig. 5, the men are well provided with locker rooms, lavatories and tub and shower baths. The heating equipment of this plant will be described in a later issue.

The writer desires to thank E. G. Lender, chief engineer, W. H. Sergeant, assistant chief engineer, and the George B. Post Co., architects of the Prudential buildings, for their assistance in the preparation of this article.

Why a Recently Blown Column Shows a Higher Water Level

It is a matter of common observation that if a water column or gage glass which has been standing so long that the water in it has become cool, is blown off, the water level indicated will be higher. The reason for this is that the colder water with which the column is filled after standing weighs more per cubic inch, and a shorter column of it will balance a longer column of hotter water.

If water be poured into a U-tube, as in Fig. 1, until it stands at the level *a* in the left-hand leg, it would also stand at the level *b* in the right-hand leg if it were of the same temperature. Suppose now the water in the right-hand leg to be heated up, this heating does not change the weight of the water in that leg, but simply its volume, and it pushes upward to *c* without pushing the level at *a* up at all, because in its heated condition the column *ec* weighs no more per unit of section than the cooler column *ad*.

In Fig. 2 it is shown that this condition does not require equality in the size of the leg, and in Fig. 3 that one of the legs of the tube may be the water column and its connections, and the other leg the boiler to which they are applied.

At 80 deg. Fahrenheit one cubic foot of water weighs

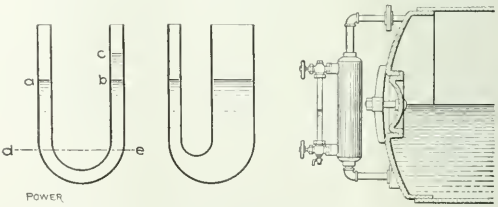


FIG. 1 FIG. 2 FIG. 3

WHY A RECENTLY BLOWN COLUMN SHOWS A HIGHER WATER LEVEL

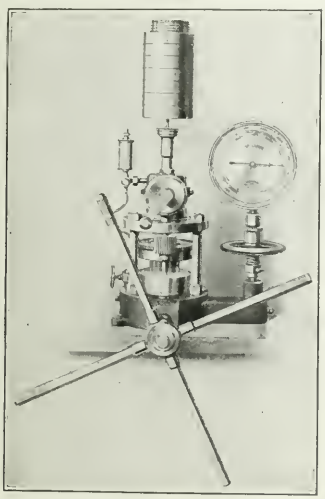
62.22 lb., at 340 deg., corresponding with the pressure of 118 lb. absolute, 55.94 lb., or only about nine-tenths as much as at the lower temperature. The cooler column would therefore have to be only about nine-tenths as high as the lighter column, or for a column 30 in. in length there might be, under these conditions of temperature, a difference of three inches.

American Multipar Hydraulic Dead Weight Tester

This is an accurate hydraulic dead-weight gage tester in which each 10-oz. weight will calibrate from 1 to 100 lb. per sq.in. pressure, and a 6¼-lb. weight from 100 to 1000 lb. pressure. Multiples of these dead weights make the tester's usefulness practically unlimited, it being as simple to calibrate a 25,000-lb. gage as one of 5 lb.

This range is secured through a simple system of multiple pistons, two of which are fixed and permanent. The top cylinder has two interchangeable pistons, the larger being used for pressures from 1 to 100 lb. per sq.in.: the smaller for from 10 lb. to whatever pressure is desired. The outfit as regularly supplied will test up to 25,000 lb. per sq.in.

The tester consists of three cylinders, three pistons and two pressure chambers—upper and lower. The top pis-



High-pressure Gage Tester

ton and cylinder give 1-lb. pressure for every ounce applied, so that a 10-oz. weight will give 10-lb. pressure in the upper chamber. This pressure is exerted on a piston 1 sq.in. in area, which is fitted into the lower part of the upper chamber. This larger piston is in direct line and in communication with a smaller piston fitted into the lower cylinder and pressure chamber. The piston in the lower cylinder has a known area which multiplies whatever force is exerted on the end of the larger piston, and the pressure thus created is communicated directly to the gage being tested.

Low pressure tests are made by opening a bypass connecting the upper and lower cylinders, which allows the pressure, created by a pressure screw in the lower chamber, to be transmitted directly to both the upper chamber and the gage being tested. The instrument is thus converted into the original direct dead-weight tester, and can be used on pressures from 100 to 1 lb. per sq.in.: pressures of less than 10 lb. can be obtained by substituting a piston supplied with the outfit for the upper cylinder which will give 1 lb. pressure for each 10-oz. weight.

The tester is made by the American Steam Gauge & Valve Manufacturing Co., Boston, Mass.

❋

Value of Boiler Specifications

By F. W. Rose

Nearly every issue of certain technical papers contains one or more accounts of boiler failures or explosions, which have been more or less destructive to life or property; many more accidents happen accounts of which never reach the technical press.

Some of these accidents could be eliminated if all boiler manufacturers were required to follow more closely high-grade specifications in the building of their boilers.

Generally the purchaser depends on the manufacturer or his agent to tell him how the boiler should be built, or, more often, the purchaser tells the manufacturer that he wants a boiler of a certain size for a certain pressure, and nothing is said about the quality of material or workmanship.

All reliable boiler insurance companies have certain standards to which boilers must conform if approved by the company.

If the purchase of the boiler is left to a responsible consulting engineer, it is his duty to see that the boiler is built according to high-grade specifications.

The following aptly illustrates the advantages of buying according to specifications.

Specifications were issued for the purchase of a horizontal return tubular boiler, and the contract was let to a supposedly reliable manufacturer of high-grade boilers. The boiler was delivered ready for erection, before an inspection was made by the consulting engineer, who rejected the boiler on the grounds that it did not conform to the specifications under which it was purchased. An inspection was then made by the inspector of a reliable insurance company. This inspector reported that 18 new tubes must be put in before the insurance company would accept the boiler. The boiler was not accepted, and another boiler was furnished by the same company, but it did not conform to the specifications, and was likewise rejected; a third boiler, which did conform to the specifications, was furnished by another company.

There was nothing special about the specifications, and any first-class boiler shop could have lived up to them if they had so desired.

The principal objections to the first two boilers were that the tubes were too short to allow for proper beading, and were weakened from excessive rolling; the first boiler was several inches shorter than called for.

In all probability either one of the rejected boilers would have been installed, had there been no specifications to which the manufacturer had to conform, and would perhaps have performed the service required. Nevertheless, there was a weakness which might have resulted in a serious accident, and after the accident there might not have been enough left of the boiler to determine the cause.

The two rejected boilers are still waiting for some purchaser who will not know the difference between a high-grade boiler and an inferior one.

Engineering Progress in the U. S. Navy

SYNOPSIS—For the conditions of service under which the American battleship fleet operates, the reciprocating engine is more efficient. In ease of upkeep, weight and space required it has the advantage and in reliability at high powers it is on a par with the turbine.

In his paper on the above subject read before the Society of Naval Architects and Marine Engineers at the New York meeting, Captain C. W. Dyson made a comparison of propelling machinery for heavy vessels of moderate speed. In this comparison were included reciprocating engines; steam turbines of the impulse and reaction types, and a combination of the two; also combinations of reciprocating engines with turbines. The relative values of turbine reduction gear, electric propulsion and internal-combustion engines for propulsion were not dealt with, as final operating data had not as yet been secured.

Speed, Horsepower and Fuel Consumption

To assist in judging the three methods of propulsion a comparison of the performances of the dreadnoughts "Delaware," "North Dakota," "Utah" and "Florida" was made, including trials in preliminary acceptance and in actual service. The "Delaware" is equipped with reciprocating engines and the other three vessels with turbines.

Due to difference in displacements and in appendages the effective horsepower required to give the "Delaware" a speed of 21 knots will give the "Florida" and the "Utah" 20.82 knots, and the "North Dakota" 21.1 knots; at 12 knots for the "Delaware," the equivalent speed of the "Florida" and the "Utah" is 12.17 knots and of the "North Dakota" 12.1 knots. Assuming that shaft horsepower is approximately 92 per cent of indicated horsepower in large, well designed reciprocating engines, and reducing the indicated horsepower of the "Delaware" to shaft horsepower, the following table of comparison results:

	"Delaware"	"North Dakota"	"Utah"
Speeds of equal e.hp.	21	21.1	20.82
I. hp. for this speed	23,400	.....	.....
S. hp. for these speeds	21,528	27,150	25,000
Propulsive coefficient equals (per cent.) e.hp. ÷ s.hp.	71.76+	56.8+	61.8+
Cruising speeds of equal e.hp.	12	12.1	12.17
I. hp. for this speed	3,600	.....	.....
S.hp. for these speeds	3,312	3,825	3,975
Propulsive coefficient equals (per cent.) e.hp. ÷ s.hp.	74+	64.1+	61.6+

While the "Florida" curve is shown in Fig. 1, that vessel is not included in the above table, as the weather conditions during her standardization trials were unfavorable and the efficiency of the propellers fell off greatly.

In Fig. 2 a comparison is made of the pounds of fuel per knot required at different speeds by the four dreadnoughts. In this figure is also shown a curve of excess fuel for the "Utah" over that required for the "Delaware," all the curves being drawn with effective horsepowers as abscissas. For the effective horsepower value required for 12 knots speed of the "Delaware," the "Utah" requires, by these curves, 22 per cent. more fuel. From the steam logs of the two vessels, the average excess fuel consumption of the "Utah" over that of the "Delaware" at 12 knots is 20 per cent., thus corroborating the results.

At the effective horsepower value required for 21 knots by the "Delaware," the "Utah" requires 1.015 times as much fuel as the "Delaware," a difference so slight as to be negligible. From the above results, it appears justifiable to decide as follows:

Should the duties of a vessel be such that she be required to steam for long periods and long distances at speeds much lower than her designed maximum speed, a less fuel expenditure per day will be required, and consequently a greater cruising radius will be obtained and less frequent recoaling necessitated should reciprocating engines be fitted rather than turbines for propelling purposes.

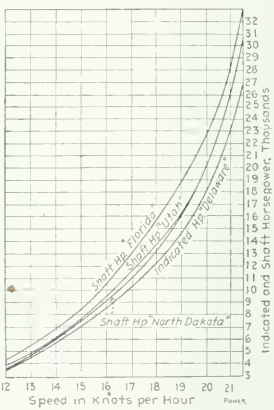


Fig. 1. Horsepower-speed Curves

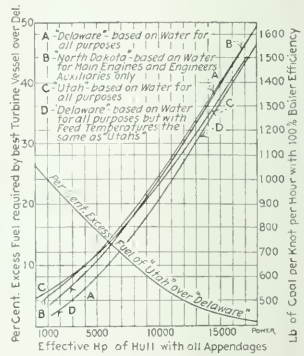

A "Delaware" based on Water for all purposes
B "North Dakota" based on Water for Main Engines and Engineers Auxiliaries only
C "Utah" based on Water for all purposes
D "Delaware" based on Water for all purposes but with Feed Temperatures the same as "Utahs"
Per Cent. Excess Fuel required by best Turbine Vessel over Del.
Per cent Excess Fuel of "Utah" over "Delaware"
Lb of Coal per Knot per Hour with 100% Boiler Efficiency
Effective Hp of Hull with all Appendages
POWER

Fig. 2. Horsepower-coal Curves for Different Speeds

Should, however, the vessel operate from a fixed base, only doing sufficient cruising to insure that the machinery is kept in efficient condition in readiness for forced runs to any threatened point, the value of fuel economy at low speeds becomes minimized and, where the maximum speed of the vessel does not exceed 21 to 22 knots, either turbines or reciprocating engines may be used, the choice being dependent upon other factors than economies, which are practically equal at these speeds.

For the conditions of service and the fuel capacity entailed under which the American battleship fleet operates, the reciprocating engine is preferable to the turbine as a propelling engine at the present stage of turbine development. The Navy Department is, however, thoroughly alive to the advantages to be gained by adopting rotary in place of reciprocating motion in the main propelling machinery of the heavy vessels of the fleet, and while recognizing the present advantages held by the reciprocating engine in the matter of economy at low fractions of designed power, holds itself ready to discard the reciprocating engine as soon as the turbine designers can demonstrate by actual performance that their claims as to equality of economy at low powers with the older machine have been realized. It was with this object in

view that the department decided to install impulse turbines in the "Nevada."

Ease of Upkeep of Machinery

The claim is frequently made by the turbine advocates that while the reciprocating engine, when new, is undoubtedly more economical than the turbine at small fractions of designed power, this advantage is soon lost in active service, due to excessive wear of piston and valve rings causing heavy leakage of steam. The turbines, not being subject to such frictional wear, would, on the other hand, retain their original economy indefinitely.

Practical experience with both types of engine in actual service comes very far from justifying this conclusion. In fact, with intelligent supervision, the reciprocating engine, particularly since forced lubrication has been applied, holds its superiority continuously.

When reciprocating-engine vessels visit the navy yards for their regular overhaul, the work to be done on the main engines is practically nil, as the machine shops and foundries of the battleships are of ample capacity to take care of all repairs that may be necessary except such as the fitting of a new cylinder or the repair of a fractured bedplate. The above remarks apply only, however, to ships fitted with forced lubrication, where the wear of bearings and journals has been practically eliminated. In a letter from the senior officer of the "Delaware," the following statements occur:

"Between July 1, 1910, and July 10, 1912, the "Delaware" has steamed 54,627 miles (knots) without a hot bearing.

"About the only wear on the brasses on the forced lubrication system is on the crossheads first, then guides and then crankpins. The wearing away of the piston rings apparently starts all the other wear."

That is, keep the pistons in line and the wear on the running parts is practically eliminated. The experience of the "Delaware" is corroborated by the experience of every reciprocating-engined vessel of the fleet to which forced lubrication has been applied. This system not only insuring efficient lubrication, but also reducing wear on all running parts, decreases the initial friction of the engines and reduces to a minimum all shock on crankpins, crossheads and main bearings, thus preventing hammering out of the white metal and wearing down out of line.

With the turbine, the case is quite the opposite. Fully 99 per cent. of the troubles that occur are internal troubles, and consist of erosion of blades and nozzles, stripping of blading, heavy corrosion of rotors, diaphragms and turbine wheels, causing destruction of balance. All of these troubles require a perfectly smooth haven in which to make repairs, and the majority of them require dock-yard facilities.

In the cases of the main engines of the three scout cruisers "Birmingham," "Salem," and "Chester," the "Birmingham," with reciprocating engines, has always been ready for service, while her two sister ships have been repeatedly laid up at the yards for overhaul of the main turbines. Evidence of experience leads to the conclusion that a battleship fitted with reciprocating engines for propelling purposes is much less apt to be forced off her station by necessary repairs to her engines than is one fitted with turbines.

Reliability at High Powers

From the natures of the two machines, it would appear safe to decide this condition as being distinctly in favor of the turbines, as this type of engine is completely free from all reciprocating parts held together by bolts and nuts. Experience with the "Delaware's" engines, however, lead to the conclusion that where proper care is taken to lock all nuts securely, and to effectively protect the engines against the shocks of reversal of direction of motion, the reciprocating engine can, even here, be regarded as nearly on a par with the turbine in reliability. The full-power 24-hr. run of the "Delaware," made without preparation immediately after her arrival home from Chile, demonstrates this reliability of the present type of battleship engines very thoroughly. The vessel put to sea, and upon getting well clear of the land a full-power run of 4-hr. was started, during which time the vessel averaged 21.86 knots per hour. Without intermission the vessel continued on for 20 hr. longer, averaging for the full 24-hr. a speed of 21.3 knots, the ship automatically slowing down as the fires became dirty and the personnel fatigued. Upon the completion of the trial a radiogram was received from the commanding officer of the vessel reporting that not the slightest disarrangement had occurred to either the main engines or the auxiliary machinery, and that she was ready for immediate service.

Minimum Weight and Space Required

As already shown, the total heat units required to be absorbed by the boilers, both for Parsons turbines and for reciprocating engines, with battleships of the speed and power that now exist, is practically the same in both cases at full power. This indicates that, for existing conditions, nothing can be saved in the boiler room weights or space by adopting turbines, as the same boiler power is required in the two cases.

In the engine rooms, for these powers, however, the reciprocating engine has a decided advantage in both weight and space required. In the "Delaware," "North Dakota," and "Utah," the engine room weights and space required are as follows:

	"Delaware"	"North Dakota"	"Utah"
Engine room weights, dry tons...	728.26	731 23	864 69
Engine room weights, wet tons...	773 26	785 93	919 80
Engine room, length, ft	44	44	60
Engine room, total width, ft...	50.5	50 5	54
Engine room, sq.ft. floor space..	2222	2222	3060

While the turbines of the "North Dakota" appear to be about on an equality with the reciprocating engines of the "Delaware" in the matters of weight and space, these turbines were extremely uneconomical. Modern turbines of this type would require an engine room more nearly equal in length to that of the "Utah," and the engine-room weights would be considerably increased.

While the reciprocating engine has a decided advantage in the features of weight and space required, under present conditions, these advantages would disappear should the necessary power to be developed be increased considerably above what is now asked for, and the advantage would rest with the turbine. Should such an increase of power be called for in future designs, or should the ordinary cruising speed be made considerably higher than now used, the Navy Department would undoubtedly abandon the reciprocating engine and adopt one of its rotary rivals for the propulsion of its capital ships.

Efficient Propellers for Maneuvering

In considering this condition, the relation of the backing power as compared with the maximum full power ahead, and the time required from full speed ahead until the vessel was dead in the water, was taken as a basis of comparison, which resulted in favor of the reciprocating engine.

Dividing the backing power by the ahead power of the "Delaware" gave 87.5 per cent. as compared to 35.1 per cent. for the "Utah." These results are corroborated by the destroyers and other vessels of the navy.

In judging the steadiness of the hull as a gun platform as affected by machinery, it seems only fair to base the decision upon the results of target practice of the vessels in service. If this is done, the decision could be given to the reciprocating type of machinery, as the "Delaware" has just won the championship of the battleship fleet, with the "Colorado," another reciprocating engine vessel, standing second on the list. From these results it appears reasonable to state that, with well balanced reciprocating engines, no ill effects on gun fire should be expected.

Basing the choice between reciprocating engines and turbines for battleship propulsion under existing conditions of speed and power, the advantage appears to rest most decidedly with the reciprocating engine.

Combination Systems

In the search for economy of propulsion through a wide range of speeds, various combinations of reciprocating engines and turbines have been proposed, both by the Bureau of Steam Engineering and by the shipbuilders, but only one of the systems has as yet been authorized, and that one is for destroyers. It has not yet been tried out in service, but preliminary shop tests show a good gain in economy of the main propelling engines at cruising speeds. This system, as applied to the destroyers, depends entirely for its gain upon the greater efficiency of the reciprocating engine at the higher steam pressures over the efficiency of high-pressure turbines of the reaction type and the high-pressure nozzles of the impulse type of turbine, no advantage being gained from increased efficiency of propellers, as the reciprocating engines are on the same shafts as the turbines. From some points of view this combination is undesirable, and the gain in service must be considerable to justify its retention.

With the other combination systems proposed, calculations indicate that if the propulsive efficiency counted upon can be obtained, these systems will all be very much more efficient than either a straight turbine or straight reciprocating engine drive at maximum power, will hold a big advantage over the straight turbine drive through all ranges of power, and will hold its advantage over the straight reciprocating engine drive until a minimum speed of about 11 knots is reached, when the efficiencies become equal.

The "if" exists, however, and is caused by the danger of the currents thrown to the rear by the big reciprocating-engine screws seriously affecting the rate of feed and direction of flow of water to the turbine propellers. In addition, there may possibly be another source of loss due to heavy leakage of steam through the large change valves which must be fitted to control the paths of flow of the exhaust steam from the reciprocating engines.

In all of these systems, to adapt them to naval requirements, it is necessary to exhaust from the low-pressure cylinders of the reciprocating engines at a pressure of not less than 25 lb. absolute, when this engine is operating at full power, and to bypass as few of the stages of the turbine as possible in order to obtain an increased economy of propulsion through a large range of powers.

[The balance of the paper, which will be abstracted in a later issue, was devoted to turbine changes, improvements in reciprocating engines tending towards increased economy and reduction in weight and a discussion of oil fuel.—Editor.]

Worthington Turbo Blowers and Compressors

Turbo-blowers and compressors have certain advantages over reciprocating compressors in various fields. In consequence of the demand growing out of this fact the firm of Henry R. Worthington, Harrison, N. J., made a comparative study of the different apparatus of this type manufactured throughout the world. This investigation covered operating efficiency and reliability as well as general design and economy, and led to the conclusion that the product of Pokorny & Wittekind, of Frankfort-on-the-Main, Germany, pioneers in this field, had shown the best results in every respect. Early in 1911, therefore, the rights for the manufacture and sale on the American Continent and in the Hawaiian and Philippine Islands, of the full line of turbo-compressors so successfully developed, were acquired by Henry R. Worthington. This firm is now in position to build and supply such apparatus for all ranges of capacity and pressure ordinarily covered by reciprocating compressors.

Turbo-blowers and compressors are quite similar, except in the matter of water jacketing and the number of stages, and are very similar in construction and principle to centrifugal pumps. The differences between centrifugal pumps or blowers and compressors are principle such as are required to adapt the compressors for handling light and elastic fluids, instead of the heavy and almost incompressible water. The success of this apparatus, however, is largely a question of engineering and shop experience and development.

Fig. 1 illustrates an experimental turbo-blower built and installed at the Harrison works for the special purpose of testing and checking the performance of the apparatus. The machine is shown on the testing floor driven by a steam turbine through a torsion dynamometer. Fig. 2 shows an end view of the testing set looking toward the blower. Fig. 3 shows a motor-driven turbo-blower of the type used for capacities of from 10,000 to 30,000 cu.ft. of air per minute at 15 lb. gage pressure. Fig. 4 is a view of a turbo-compressor driven by a mixed-pressure turbine and having a capacity of 10,000 cu.ft. of air per minute against a presure of 1000 lb.

Centrifugal and turbo-blowers and compressors consist simply of a stationary casing inclosing a rotating element supported in bearings. The casing may contain one or a number of impellers, depending upon the pressure desired. The impellers, carried upon a shaft equipped with a thrust bearing, constitute the rotating element. The casing has a suction and a discharge opening and is divided into as many cells or stages as there are impellers. Leakage about the shaft and between the stages is prevented by labyrinth packings.

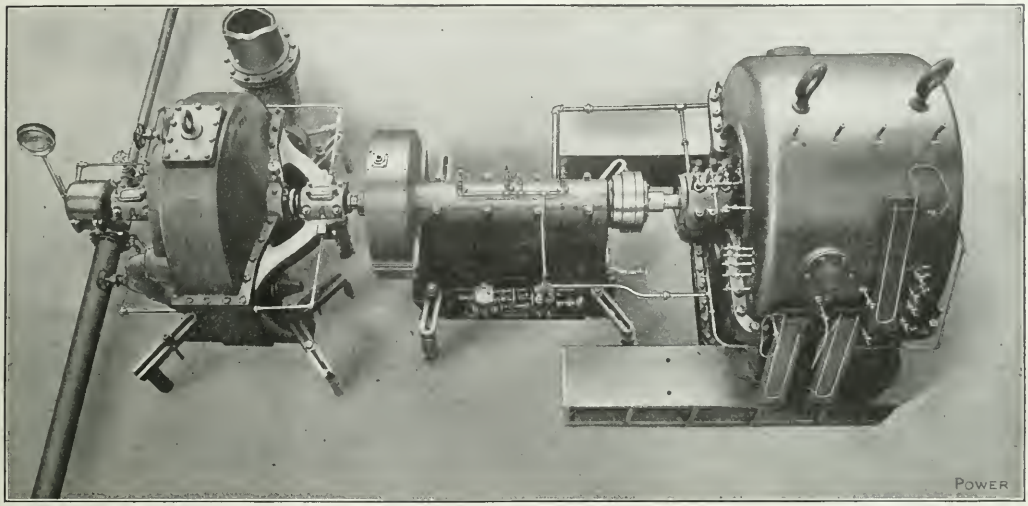


FIG. 1. BIRDSEYE VIEW OF AN EXPERIMENTAL TURBO-BLOWER UNDER TEST AT THE WORTHINGTON WORKS

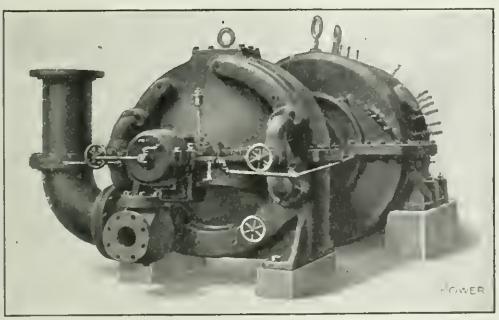


FIG. 2. END VIEW OF THE TURBO-BLOWER

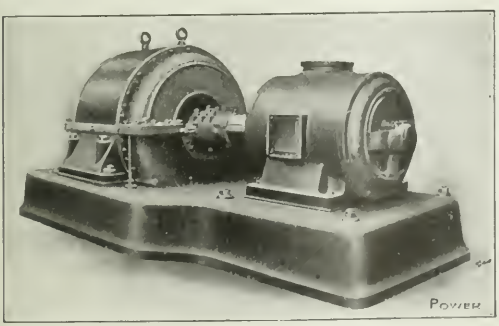


FIG. 3. TURBO-BLOWER

The air enters the suction pipe at low velocity and is guided to the impellers by directing vanes; in passing through the impellers the pressure and velocity are increased. Leaving the impellers the air is received by a ring of diffusion vanes which convert a large part of the velocity into pressure and greatly reduce the leakage losses. Upon leaving the first set of diffusion vanes, the air at reduced velocity, flows by easy curves to the influx chamber preceding the next impeller. This process is repeated for each stage until the exhaust is reached.

A light and compact prime mover can be used as, owing to the high rotative speeds, the prime mover and the compressor can be directly connected; moreover, whether the prime mover is an electric motor, or a high-pressure, an exhaust or a mixed-pressure turbine, it can

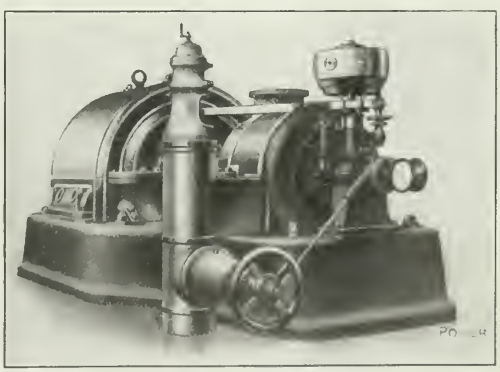


FIG. 4. TURBO-COMPRESSOR

be operated at its most desirable speed. High efficiency is maintained throughout the life of the machine.

Other advantages of turbo-compressors over other types may be summarized as follows: Low first cost; minimum attendance; continuous even flow of air; compact construction; light weight; small foundation and installation expense; minimum upkeep charges; simplicity of construction, insuring ease of operation and minimum of attention; long life, due to few rubbing parts and rugged construction; absence of valves, which are troublesome and cause loss of efficiency; low friction loss, due to the few rubbing parts; absence of packing trouble; absence of vibration, and economy of lubricants.

ELECTRICAL DEPARTMENT

Ground Detectors

By R. L. Mossman

The diagrams show the various methods of connecting lamps and voltmeters as ground detectors, also the electrostatic detector as used on high-voltage alternating-current circuits. A ground detector is an important instrument on a switchboard and should be used frequently; when a ground shows on a line it should be cleared as soon as possible, for if the line of opposite polarity should ground a short circuit and interruption of the service would result.

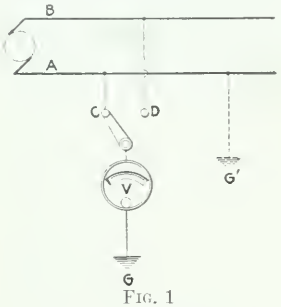


FIG. 1

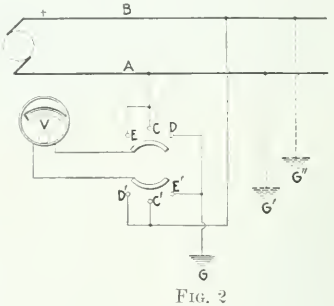


FIG. 2

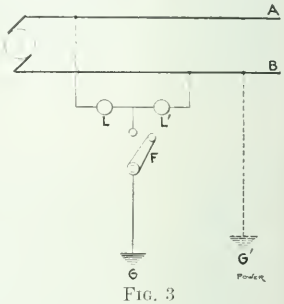


FIG. 3

A voltmeter makes a very good ground detector, because it not only indicates whether a ground is present, but by its deflection shows whether the path of the current to the ground is one of high or low resistance. Fig. 1 shows one way of connecting a voltmeter on a two-wire circuit. If the line A should be grounded as indicated by the dotted line at G' and the switch placed on C no deflection would result. If the switch is moved to D current will pass from line A through the ground on the line through the voltmeter to point D, thence to line B, thus completing the circuit. When the deflection is obtained on D it shows that line A is grounded; when obtained on C it shows line B is grounded.

If the ground is of high resistance the deflection will be small, if of low resistance it will be large. In using a voltmeter connected in this way, it must have its zero point in the center of the scale, as the current will flow through it in the opposite direction on point C from what it will on point D. A voltmeter having its zero point at the left of the scale can be connected as in Fig. 2 which is a better method. It can then be used either as a voltmeter or as a ground detector. When the switch is in position CC' the voltmeter is connected directly across the line and gives the voltage on the system; when in position EE' it will indicate a ground on line B, as at G''. When in position DD' a deflection will indicate a ground on the line A as G'.

Fig. 3 shows a common arrangement where two lamps L and L' are used in series; each lamp should be for the same voltage as that of the circuit, which will cause them to burn half of their rated candlepower. A connection is made to ground through switch F. When contact is made at F and there is no ground on either line the brilliancy of the lamp will not be altered. If there is a ground on B, as at G'', lamp L' will go out or burn dim and L will burn brighter according to the resistance of the ground; if the ground is on A, L' will burn brighter. This is a simple and very good ground detector when a voltmeter is not available.

Fig. 4 shows a lamp ground detector suitable for a three-wire low-tension system. Three lamps, L, L' and L'', are connected in series across one side of the system, and a ground connection is made at K. When all three lines are clear of grounds the lamps will burn equally when K is closed. If line C becomes grounded at G', L and L' will go out or burn down, and L'' will become brighter. If line B is grounded L'' will become dim while L and L' become brighter. If the ground is on A all the lamps will become brighter, because all will get the full voltage, L'' being across A, B, and L and L' in series across AC. These detectors are applicable more particularly to low-tension direct-current installations.

In Fig. 5 is shown a voltmeter detector on a three-phase system, the voltmeter being connected through a

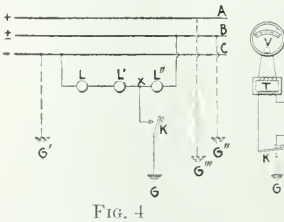


FIG. 4

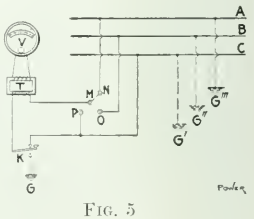


FIG. 5

transformer T. A plug switch is used to connect across from M to N, O and P. When across M and N and the key K is pressed, it will show a ground on B or C; when across M and O, a ground will show on A or C; when across M and P, it will show a ground on A or B.

Electrostatic ground detectors are much used on high-tension, alternating-current switchboards. They have the advantage that they require no current for their operation and may be left connected to the circuit all the time, thus indicating a ground as soon as it occurs. They also give an indication without its being necessary to make an

actual connection between the line and the ground, as is the case with all the detectors previously described. The principle of a Stanley electrostatic ground detector is illustrated in Fig. 6. This is especially adapted to high-tension, alternating-current lines, because the instrument is not in actual connection with either of the lines.

The fixed vanes, *M*, *N*, *O* and *P*, are connected in pairs as shown. The movable vane *V* is connected to the ground at *G*, and is held in the central position as shown

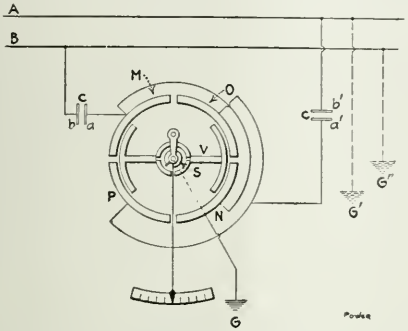


FIG. 6

by the small spiral spring *S*. The pairs of fixed plates are not connected direct to the lines, but are attached to plates *a a'* of two small condensers which consist simply of two brass plates, mounted in hard rubber but separated from each other. Plates *b* and *b'* are connected to the lines. When no grounds are present, *MN* and *OP* become oppositely charged by reason of charges induced on the plates *a a'* by plates *b b'*, the forces acting on vane *V* are therefore equal and opposite. Now assume line *B* to be grounded at *G''*. This is equivalent to connecting

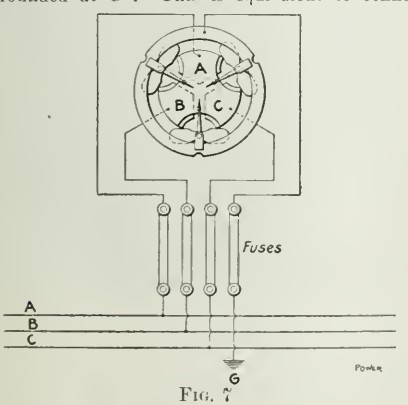


FIG. 7

vane *V* to line *B* and *V* takes up a charge similar to *O* and *P*, hence, it is repelled by *O* and *P* and is attracted by *M* and *N*, thus giving a deflection. If *A* becomes grounded, a deflection in the opposite direction is obtained.

Instruments of this kind can, of course, only be used where the voltage is fairly high, as the electrostatic forces produced by charges due to low voltages would not be large enough to operate an instrument unless it were made much too delicate to be of practical use in a power house. In most electrostatic detectors the lines are connected directly to the fixed sectors, and the condensers *cc* are omitted.

Fig. 7 shows a General Electric three-phase electrostatic detector without condensers. It is practically three single-phase detectors combined in one instrument. When no ground exists, the three needles point toward the center. When a ground occurs on one of the lines, the two adjacent needles are deflected toward the segment to which the grounded line is connected. Should a ground occur on two lines the needle between the segments connected to the grounded line will be deflected toward the one having the lower resistance ground and the two remaining needles will be deflected toward the grounded segments.

The Turbo Converter

A novel machine was described by F. Creedy at a recent meeting of the British Institution of Electrical Engineers. It is intended to overcome the difficulty of commutation often troublesome in high-speed turbo-generators of large output, which fact led H. M. Hobart to propose that when continuous current is required, a turbo-alternator be used in conjunction with a rotary converter. Mr. Creedy, in fact, follows this suggestion to the extent of using a turbine to drive a converter, but not a rotary converter of the ordinary type; instead, he employs a "motor-converter," very similar to the machine known by that name and invented by Messrs. Bragstad and La Cour, which has become widely used in England on account of its cheapness and efficiency.

In the motor-converter there are really two machines—an induction motor and a rotary converter driven by the motor. The winding of the rotor of the motor is connected by conductors through a hollow shaft with the armature of the converter, at suitable points, and about half the power is transmitted to the converter through these windings, while the other half is transmitted mechanically through the shaft, driving the converter as an ordinary continuous-current generator. The result is that the combined machine runs at half the speed at which the motor would run if it were not coupled to the converter, and possesses other advantages which, however, need not be mentioned here. Mr. Creedy availed himself of the reduction in speed to permit the commutator of the continuous-current part of the machine to work under better conditions than obtain in the case of a dynamo directly coupled to a turbine.

In the turbo-converter, the induction motor is replaced by an induction generator, the squirrel-cage rotor of which is mounted on the shaft of the turbine and therefore driven by the latter. This construction is particularly favorable, as the rotor can be very strongly built, and is easily capable of withstanding the high speed of rotation, sometimes as high as 3000 r.p.m. The "primary" of the generator, as it is called, though the name is not very appropriate, revolves round the "secondary" or rotor, but is in no way connected to the turbine shaft; it is carried on the shaft of the converter, as shown in Figs. 1 and 2. The primary is driven by the torque due to the currents circulating in the secondary and primary, and the currents generated in its windings are led by insulated conductors through the hollow shaft to the armature of the continuous-current part of the rotary

converter, in which they are converted to continuous current. The torque which drives the primary is transmitted mechanically through the shaft to the armature also, and drives the latter as a generator. Thus the whole output of the turbine, less losses, appears on the continuous-current commutator.

Now, the speed of the converter armature, as in the case of the motor-converter previously referred to, is only half

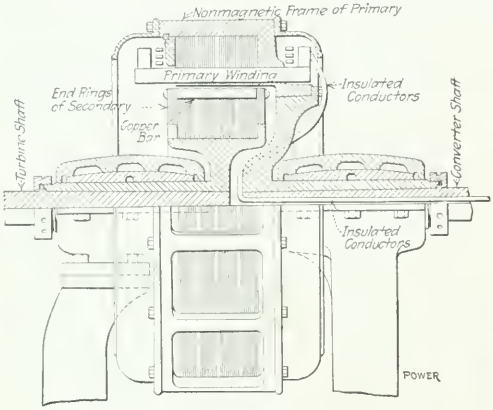


FIG. 1. SECTION THROUGH WINDINGS

that of the rotor or secondary on the turbine shaft, if the alternating- and direct-current machines both have the same number of poles; and it may be slower still if desired, the ratio of speeds being the same as the ratio of the number of poles on the induction generator to the number of poles on both machines added together. Thus with a two-pole induction generator and an eight-pole converter, the armature of the latter would run at one-fifth the speed of the turbine. This high ratio, however, would entail increased cost of construction. It will be

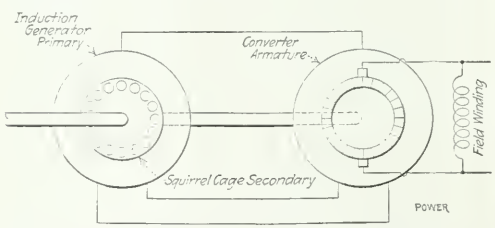


FIG. 2. DIAGRAMMATIC ARRANGEMENT OF GENERATOR AND CONVERTER

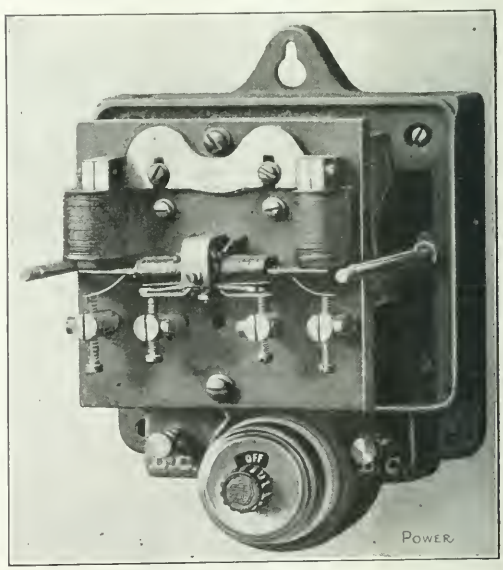
noticed that the design of the induction generator has been so contrived as to reduce the amount of overhang of the rotors to the smallest possible amount, and the joints between the hubs and the two shafts have been carried through the bearings for the same reason. The design of the converter portion of the set, however, is on the usual lines.

The advantage of the system as compared with that of Mr. Hobart is that, whereas in the latter the alternator and the rotary converter would each have to be capable of dealing with the whole output of the turbine, in the Creedy system each machine need only be large enough to carry half the total output.

Rectifier for Charging Three-Cell Batteries

The rectifier illustrated herewith is intended for charging three-cell lead storage batteries, such as are used for automobile or gas-engine ignition and for lighting automobiles from an alternating-current circuit. It is of particular benefit to the motor-car owner who has a three-cell battery equipment, as it enables him to charge his batteries at home at small expense and with no trouble whatever, directly from his lighting circuit.

The apparatus consists essentially of a polarized relay acted upon by two alternating-current magnets so that it vibrates in synchronism with the alternations of the current, and arranged to reverse the connection of the circuit as the current reverses. The vibrating arm is magnetized by current from the direct-current side, so that one end is permanently North and the other end permanently South, depending on the way the battery is connected. The two stationary electromagnets are wound so that their lower ends are of the same polarity at each instant. When the alternating current is in one direction the lower poles of both stationary magnets are North, attracting the south end of the vibrating arm



RECTIFIER WITH COVER REMOVED

and repelling the north end. This connects the alternating-current to the direct-current circuit in one direction. When the alternating current reverses, the pole of the alternating current magnets become South, attracting the north end of the vibrating arm and repelling the south end. This reverses the connection of the alternating-current to the direct-current circuit, but as the direction of the current has also reversed, the current flows into the direct-current circuit in the same direction as before. The reversal of the connections thus takes place every time the current reverses, so that the result is a pulsating direct current. A transformer reduces the voltage to the proper value.

GAS POWER DEPARTMENT

Ignition from Dry Cells

By A. L. Brennan, Jr.

Although manufacturers of storage batteries have made progress during the past few years in raising their product to a high standard of efficiency, still many members of the old school adhere to the notion that dry cells are in many respects superior to any other chemical means of producing a primary current. This idea has been handed down from one gas-engine operator to another with the result that it would now be quite out of the question to dispense with them.

A few years ago when many operators attributed the majority of their engine troubles to the electrical source, the batteries were not at fault in every instance, but nevertheless, were far from perfect. This, however, does not hold true of the present-day cells, although they do occasionally give trouble in the hands of inexperienced operators. With this in mind the following notes have been prepared to enlighten the inexperienced sufficiently to understand the why and wherefore of dry cells.

There are several features to be considered when employing dry cells to furnish a primary current, which have to do directly with the cells themselves, while, on the other hand, there are other points to be looked after, which indirectly interfere with maintaining sparking efficiency on a low rate of current consumption.

In the first place, the cells should be kept in a dry place and fully protected from contact with any other element. The wiring should be of ample size, all connections firm and the contact surfaces of the terminals sufficiently large to cause no hindrance to the current. This feature in the wiring is often overlooked. Some wire is composed of strands which are apt to become separated, some of them breaking off, thus reducing considerably the carrying capacity of terminals of the wire; also the switch contacts may be at fault.

Present competition has rendered the production of coils and other parts of the ignition system far in advance of what they were a few years ago, and at present the several appliances to be had are representative of the latest means of combining high efficiency in conjunction with low discharge rate from the battery. These conditions, however, are entirely in the hands of the operator. He may have at his disposal a thoroughly modern coil but, through poor adjustments or other causes, the results may be very poor. On looking into the matter it may be found that a small wire offering considerable resistance to the current is the cause of apparent battery exhaustion—a cause in no way allied to the source of the primary current.

Coil Adjustments

Faulty coil adjustments are also largely responsible for supposed battery faults. By increasing the tension on the vibrator the demands made upon the battery will be greater and in many cases with no material advancement in the output of the engine. It will be found that having obtained a spark of sufficient density to ignite the compressed mixture and the motor is once in operation that the tension on the trembler can be materially altered without apparent change in the running—either increasing or decreasing the amount of energy taken from the battery. This goes to show that to get positive ignition, but at the same time to utilize as little battery current as possible, the several component parts of its ignitor system will have to be adjusted to suit one another.

Considering a spark plug, for example, much is heard about keeping the parts of a spark plug tightly assembled the points clean and the connections of the secondary wires secure; but what distance apart should the points be set? Some authorities recommend $\frac{1}{16}$ in., some less and others more, and the query naturally arises—who is right? It may be said that all are correct as far as the actual operation of the motor is concerned, for with adequate coils and batteries the varying spark gaps can be easily taken care of, but this discrepancy of spark-plug adjustment is accompanied by material loss in some cases and invariably the battery is held responsible.

To correct this very prevalent fault, the spark-plug gap should be as short as possible; that is merely long enough to produce positive firing. Also, the coil should be adjusted to its minimum rate of current consumption, which adjustment can only be carried out when the motor is in operation and working under its ordinary load. Positive and ample contacts at all times are necessary.

On testing a spark plug under ordinary conditions (atmospheric pressure) it is found that much less electrical energy is required than that necessary when the plug is in the cylinder and the spark occurs under the high compression pressure of the combustion chamber.

This point can be readily proved by disconnecting the wire at the plug, unscrewing the plug from the cylinder, connecting the wire as before and placing the threaded section of the plug on the cylinder, then turning the engine over to the firing point, having the switch in the battery contact position. A buzz will be heard when this point has been reached, providing the trembler is adjusted approximately, if not, watch the contact points at the timer, for when they are together the motor is on the firing point.

If this method cannot be followed observe the marks on the flywheel or test the piston with a wire to find when the top center on the compression stroke is reached. When the firing point is found, adjust the coil to produce a spark with the least possible tension on the trembler. Having completed this step, insert the plug in the cylinder, wire and attempt to start. It will be found difficult, however, to get the motor to pick up until the tension on the vibrator has been materially increased. This experiment fully bears out the point that more electrical energy is required to produce an arc under high pressure than under ordinary conditions.

Bearing this point in mind not a few conceive the idea that gas could be more readily ignited at low pressures,

but this is an erroneous notion, for gas is far more susceptible to ignition when compressed. Thus it is found that although it takes decidedly more electrical energy to produce an arc in high pressure, still there is not such a demand made upon the battery as in the case of attempting to operate a motor which is not capable of producing high compression.

Defective mixtures are another element which sometimes very materially affect consistent engine operation and lead one to suppose the ignition is at fault. In cases of this kind one of the first remedies suggested is a tighter adjustment of the contact points which in some cases may appear to better the conditions, but the motor should operate without this latter adjustment which can only result in overtaxing the battery to a certain degree.

Recuperation of Battery

The points already considered are those dealing with how to minimize and maintain efficient operation on a low expenditure of battery current and although of great importance there are other features of equal value.

For instance the time allowed for recuperation is also to be considered if lasting efficiency is desired from the cells. It is not altogether feasible to suggest any strict rules to be followed in this respect, for much depends upon the method employed in connecting the cells. Assuming, however, that six cells are used in series it will be found in practice that continuous operation rapidly decreases the amperage and that considerable time must be allowed for recuperation. To remedy this defect two methods are offered. The first is to use two sets of cells of the required voltage alternately. A two-way switch should be employed and during operation switch from one set to the other about every two hours. This method will greatly increase the life of the cells and insure high efficiency.

The second method is to connect the cells in series-multiple which is perhaps superior to the first. First connect the cells in series in numbers sufficient to give the required voltage and place these sets of four to six cells in multiple by connecting the negative posts together and also the positive posts. Cells connected in this manner give the lowest rate of discharge in amperes per cell at an increased ratio according to the number of series sets in line. But it is not a good plan to carry this method to extremes, for the deterioration while not in operation is considerable; besides the cash investment and space required should also be considered.

Alcohol vs. Gasoline Engines

A few years ago the alcohol engine was much discussed in engineering circles and many went so far as to predict that it was only a matter of a few years before it would entirely displace the gasoline engine. Contrary to these expectations, however, the past four or five years have witnessed unprecedented advances in gasoline engine development; not only have they been greatly improved in design and construction but the number in use has increased enormously. In striking contrast to this, the alcohol engine has practically dropped out of sight, and with the exception of a few laboratories is nowhere to be found in actual operation.

Recently we have received a number of inquiries, from readers, as to the cause of these conditions and as to the comparative performances of gasoline and alcohol engines. Perhaps one of the most exhaustive investigations into this subject was that conducted by Messrs. Strong and Stone for the Bureau of Mines. This investigation extended over several years and the results have recently been made public in bulletin No. 43.

Without going into the details of the tests but quoting in substance from the report, it says:

The lower heat value of completely denatured alcohol averages 10,500 B.t.u. per pound, or 71,900 B.t.u. per gal.; whereas, the lower heat value of gasoline having a specific gravity of 0.71 to 0.73 averages 19,200 B.t.u. per lb. From this it will be seen that the best value of 1 lb. of alcohol is approximately six-tenths that of gasoline.

However, 1 lb. of gasoline requires about twice the weight of air for complete combustion that is required by 1 lb. of alcohol. Hence, the heat value of 1 cu.ft. of an explosive mixture of alcohol vapor and air having theoretically just sufficient air for complete combustion is approximately equal to that of 1 cu.ft. of a similar mixture of gasoline vapor and air—about 80 B.t.u. per cu.ft.

Explosive mixtures of alcohol vapor and air in an engine cylinder can be compressed to much higher pressures without preignition than explosive mixtures of gasoline vapor and air. The maximum compression that can be used in an engine without causing preignition depends on the quality of the explosive mixture, the design of the engine, and the speed at which it is operated.

For 10 to 15-hp., four-stroke-cycle stationary engines a compression pressure of about 70 lb. per sq.in. above atmospheric pressure was found to be the maximum that could be used for gasoline mixtures and about 180 lb. the maximum for alcohol engines, without causing preignition.

The maximum compression that could be obtained without causing preignition was in each case found to be the most advantageous with regard to fuel economy.

A gasoline engine having a compression pressure of 70 lb., but otherwise as well suited to the economical use of denatured alcohol as gasoline will, when using alcohol, have an available horsepower about 10 per cent. greater than when using gasoline. When the fuels for which the respective engines are designed are used to the same advantage, the maximum available horsepower of an alcohol engine having a compression pressure of 180 lb. is about 30 per cent. greater than that of a gasoline engine having a compression pressure of 70 lb., but of the same cylinder diameter, stroke and speed. Moreover, an alcohol engine can, in general, be so designed and constructed as to equal the gasoline engine in adaptability to service, and when working at the degrees of compression best suited to the fuel supplied, requires about equal volumes of gasoline and denatured alcohol per brake horsepower-hour.

A fair idea of the best economy obtained in tests on engines of 10 to 15 hp. will be gained from the following tabulated results:

Fuel	Compression Pressure	Fuel per b.hp.-hr.	
	Pounds per sq.in.	Pounds	Gallons
Gasoline	70	0.60	0.100
	90	0.58	0.097
Alcohol	70	0.96	0.140
	180	0.71	0.104
	200	0.68	0.099

When denatured alcohol is used in 10- to 15-hp. four-stroke-cycle engines having a compression pressure of approximately 180 lb. and the engines are operated at their maximum loads, explosion pressures reach 600 to 700 lb.

From the foregoing it will be seen that under the proper conditions of compression, etc., the alcohol engine is as efficient as the gasoline engine or perhaps more so. Therefore, one must look to other causes to account for its disuse. A little study will show that it is purely an economic question; the price of denatured alcohol still remains prohibitive as compared with gasoline and not until these prices are more nearly equalized will the alcohol engine attain commercial success.

Research Work on Large Diesel Engines

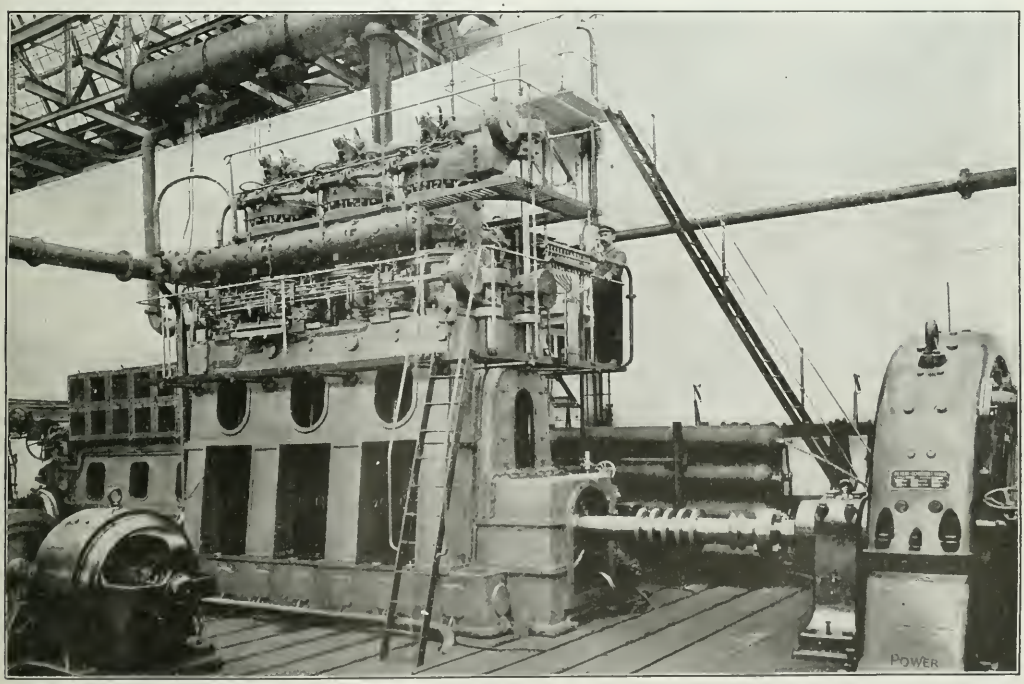
Among the firms which have contributed to the successful development of large Diesel engines in Europe, that of Blohm & Voss, shipbuilders, in Hamburg, rank second to none. Considering the great expenditure required for experiments of this character and the limited capital at the disposal of the individual concern, it is but natural that the tendency of manufacturers in Germany is to combine their financial forces in order to secure results in this complicated and expensive line of machine building. Accordingly, a research association was formed some time ago between the Maschinenbaugesellschaft Nürnberg and the aforesaid firm in Hamburg for the purpose of building large Diesel engines separately, testing details of construction, and exchanging the results.

The first engine built on this basis in Hamburg is herewith shown. It has three cylinders of 480-mm. bore and 650-mm. stroke (18.7x25.3 in.), developing 1000 b.hp. This engine has been on the testing floor of Blohm & Voss for 18 months and various experiments have been conducted with it, the purpose being to establish some fundamental deductions for the standard design of large double-acting two-stroke-cycle Diesel engines.

The research has been directed chiefly toward the evolution of reliable stuffing boxes, of suitable and safe covers for the lower cylinder sides, and of a simple governing gear. All these problems can now be considered as solved, and the firm is ready to guarantee the operating safety and durability of large double-acting Diesel engines. In other words, the difficulties attendant upon the double-acting principle have been practically overcome and it remains to study the difficulties associated with the heat conduction from the cylinder walls.

A new combination consisting of two three-cylinder units having an aggregate capacity of 2400 hp., and another of two single-acting, two-stroke-cycle, four-cylinder units with an aggregate output of 4000 hp., will be ready for testing early this year.

The new engines have an open frame and the scavenging pumps which, in the first experimental engine, were arranged on the prolongation of the shaft, are at the side, actuated by balance levers. The policy of Blohm & Voss is to build two-stroke-cycle engines up to 3000 hp., single-acting, and above this double-acting. This is because the complications involved in the double-acting engine are not welcomed by the operating attendants, who, in the smaller plants, do not often possess the required ability, and because up to sizes of 3000 hp. the economies to be realized as to space and weight are inconsiderable.



Large Double-acting Diesel Engine on Testing Floor of Blohm & Voss

HEATING AND VENTILATION

Graphical Solution of Heating Problems

In *The Wisconsin Engineer*, Prof. H. J. Thorkelson presented a useful chart for determining areas and cubical contents and an ingenious circular slide rule for calculating radiating surface. Both had been constructed by former students of the University of Wisconsin.

In meeting problems of heating and ventilation of the recent university buildings, the general plan followed was to provide direct radiation in the rooms to supply the heat necessary for the usual radiation and convection losses, and to install such additional indirect heating surface as required to heat the fresh air used for ventilation to room temperature. The direct radiation surface required for rooms was computed by deriving a formula based on the following heat losses per degree difference of temperature per hour per unit used: Radiation, glass, 1 B.t.u. per sq.ft.; wall, 0.25 B.t.u. per sq.ft.; convection 0.04 B.t.u. per cu.ft.

As outdoor temperatures of —20 deg. F. are frequent, it was necessary to base calculations on a 90-deg. difference of temperature, giving an hourly heat loss of

$$90\ (G + 0.25\ W + 0.04\ C)$$

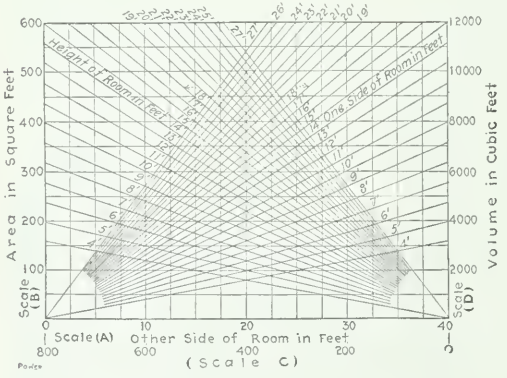


FIG. 1. AREA AND VOLUME CHART

where

G = Square feet of window opening;

W = Square feet of net exposed wall surface;

C = Cubical contents of the room.

With a heat transmission of 300 B.t.u. per sq.ft. of radiator surface per hour by a steam radiator, the above formula would indicate a radiating surface of

$$\tfrac{90}{300}\ (G + 0.25\ W + 0.04\ C) = 0.3\ (G + 0.25\ W + 0.04\ C)$$

and this was the formula used to determine the square feet of radiating surface.

To expedite calculations of this kind the chart shown in Fig. 1 will be found convenient. Areas are found by using the inclined lines from the lower left-hand corner and scale A for the two dimensions with the product shown on scale B.

If volumes are desired, the area is found as indicated on scale B and this result is transferred to scale C and followed in a vertical line to the dimensions of height shown on the lines radiating from the lower right-hand

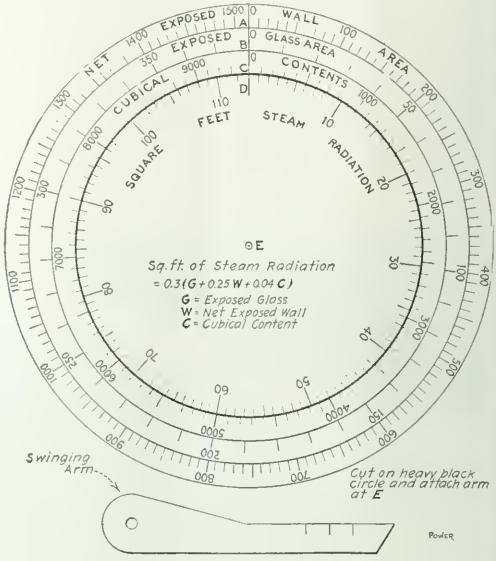


FIG. 2. CIRCULAR SLIDE RULE FOR DETERMINING RADIATION

corner; the volume will be shown in scale D. This enables easy calculations of G, W and C.

For simple calculations of the required radiating surface from the formula given the slide rule shown in Fig. 2 may be used.

Scales A, B and C are cut out in one piece, forming the movable scale of the slide rule, and D the fixed scale. A swinging arm is fastened to the center of the rule, and in starting both scales are set at 0. The swinging arm is then moved on Scale B to the figure indicating G of the formula, and held there. The movable scale is then revolved until its zero coincides with the swinging arm. This arm is then moved on scale A to the figure representing W of the formula and held there.

The movable scale is then revolved until its zero coincides with the swinging arm. This arm is then moved on scale C to the figure representing C of the formula. Scale D will then show the square feet of steam radiation required.

If a gravity hot water system is used this result should be multiplied by 1.5 to obtain the required square feet of hot water radiation. If forced circulation is used this ratio may be reduced.

A New Arrangement of Heating Boilers

By Dr. Alfred Gradenwitz

Extensive heating plants supplied from a central boiler set have become more and more general of late years. Heating boilers had, accordingly, to be given ever larger dimensions, thus taking up more room and becoming more exacting as far as their superintendence is concerned.

Messrs. Gebrüder Sultzer's new large size boiler, which is shown in Figs. 1 and 2, and, like smaller heating boilers, is made up of several cast-iron units, is a decided advance in this connection. This boiler allows of convenient operation up to the following maximum dimensions: width, 5.9 ft.; height (including platform), 5.9 ft.; length 6.9 ft.

The heating area of a hot-water boiler of this size, by computation is 403.65 sq.ft., the grate surface 10.14 sq.ft. and the output under normal working conditions 1,270,000 B.t.u. per hr. The smallest size of this type of boiler is 3 ft. 3 in. in length and under normal working conditions it yields 555,550 B.t.u. per hr.

Low-pressure steam boilers apart from the fittings, have the same outward appearance, their top part serving as the steam compartment. On account of the low water level, the heating area in contact with water is, of course, somewhat smaller than the heating area of hot-water boilers of the same external dimensions. This would be 363.8 sq.ft. in the largest size boilers, the output being 1,113,000 B.t.u. at normal loads. The smallest size boiler of this type has a heating area of 157 sq.ft., the normal output being 778,000 B.t.u. per hr.

Fig. 3 illustrates the efficiency of the boiler at various loads, its coal consumption, flue-gas temperatures and the intensity of draft in the flue. These are the results of careful tests made on a hot-water boiler of 294.9 sq.ft. heating area, by the Swiss Association of Steam Boiler Owners. It may be noticed that the maximum efficiency has been found to be upwards of 86 per cent. while the average flue-gas temperature even at forced loads remained below 390 deg. F. These results have been exceeded on boiler plants in permanent operation with the government authorities of several states.

Fig. 1. Front View of Boiler

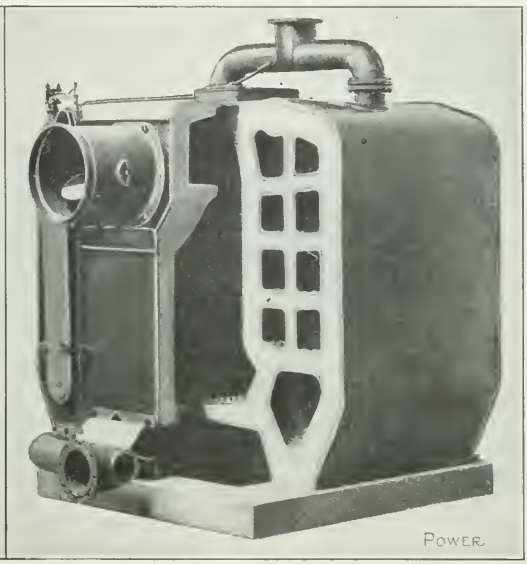


Fig. 2. Rear View of Boiler

If the heat consumption of a heating plant becomes so considerable that a single boiler is no longer sufficient, two or more boilers are combined. To reduce the space requirements to a minimum, the boilers are installed in batteries, being covered by common plates as represented in Fig. 1, which is a photograph of a low-pressure steam boiler plant recently installed at Schaffhausen, Switzerland. It comprises six furnaces of which any number can be operated at a time. The ground area covered by the boilers is 35.1x6.2 ft. = 220.7 sq.ft., the height from

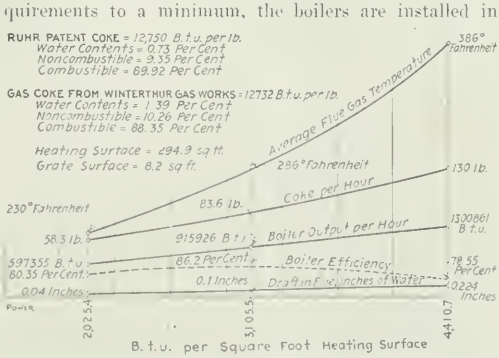


Fig. 3. Curves Plotted from Test Data

the floor to the platform being 7.87 ft. The total heating area in contact with water is 1976.3 sq.ft. and the drying surface in contact with steam 219.6 sq.ft.

The normal output of this set of steam boilers proves to be 6,214,000 B.t.u. per hr. As, however, further units are to be added, the total output after the ultimate completion of the boiler plant will amount to 15,872,000 B.t.u. The total coke-filling space for the time being, is 205.5 cu.ft., so that the boiler can run, without replenishing for about ten hours.

In these boilers the fuel may be readily inserted through an upper hopper on the platform and distributed by means of the door in the front wall. Sheet metal chutes, through which the coke slides down automatically from an elevated bunker, may be provided and the fuel may be conveyed from the store directly above the hoppers in trucks traveling on rails suspended below the roof. The flues run horizontally and after opening the front and rear doors, they can be cleaned without interfering with the service.

In Fig. 4 may be seen the gage glasses near the upper ends of the flue doors, as well as a vertical mercury gage for each boiler. At the bottom is the ashpit drop door.

exercise their ingenuity to make a two-pipe radiator work quietly on a single-pipe system, or *vice versa*, but it can be done as Figs. 1 and 2 will show.

Fig. 3 shows methods of connecting a pipe coil on a single-pipe system. If the coil is long and the difference of pressure between the inlet and outlet is considerable, the discharge leg of the seal should be made the shorter to get the benefit of the head on the other leg.

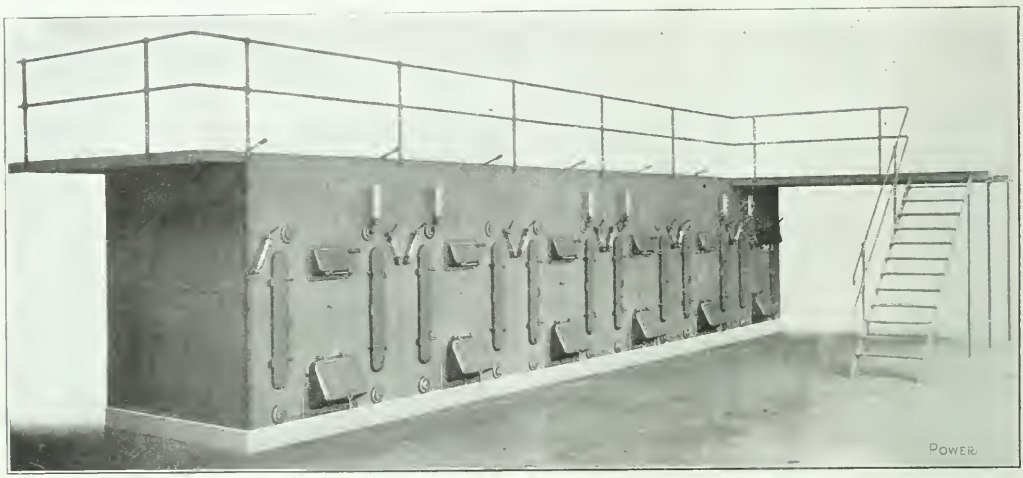


FIG. 4. A BATTERY OF SIX BOILERS

When it is necessary to put a pocket in the steam-supply pipe to get to a coil on the ceiling, it may be drained into the return as shown in Fig. 4. If there is any doubt about the necessity of a seal in a return or drip pipe, be on the safe side and put one in. One unsealed connection to a line is generally allowable and is sometimes advisable. Each installation has its own problems and laying out the piping on paper first will greatly simplify the work. The obstacles will be anticipated, so that the installation work will be straightforward and there will be no occasion to reconstruct or modify any part of the system.

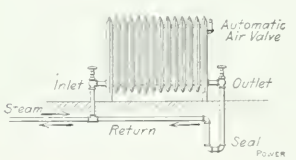


FIG. 1. TWO-PIPE RADIATOR ON SINGLE-PIPE SYSTEM

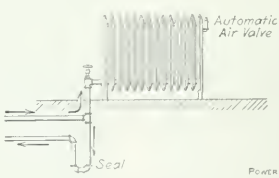


FIG. 2. SINGLE-PIPE RADIATOR ON TWO-PIPE SYSTEM

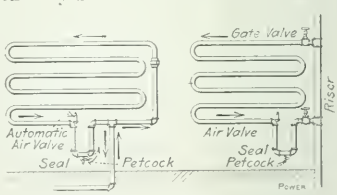


FIG. 3. COIL CONNECTIONS IN SINGLE-PIPE SYSTEM

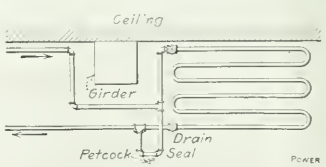


FIG. 1. DRAINING A POCKET INTO THE RETURN

Radiator and Coil Connecting

BY W. T. MEINZER

Engineers are often furnished with a nondescript lot of radiators and told to go ahead and heat up a building or add to an existing installation. They have to ex-

EDITORIALS

Review of the Year 1912

As a whole the year 1912 was marked by little that was sensational in the power field, but it was a year of steady growth in nearly all lines. The best thought has been put to the development to the point of greater commercial usefulness of nearly all standard parts in the equipment of the power plant. Very many smaller improvements, far too numerous to mention within the scope of a review such as this, have been made, but in the following it will be attempted to enumerate only the most important events of the year.

Ever increasing attention is being given to the obtaining of higher efficiency in the making of the steam. To this end greater interest is being shown in flue-gas analysis and combustion recorders that firing may be improved. More opportunity to increase over-all efficiency is open in this direction than any other. In the last year considerable space has been given to the subject in these pages, and it is felt that the knowledge of this hitherto somewhat ill-understood phase of steam-plant operation is growing.

Applications of superheated steam are extending. The advantages realized from its use in steam turbines and locomotives, have led to new efforts to use it upon the part of those designing reciprocating engines, and notable steps have been taken to overcome the difficulties that were involved.

The necessity of the use of separators is being recognized, for although superheated steam is normally dry, local condensation may occur and can exist even in a surrounding of superheated steam. The elimination of moisture is especially important where the steam is used in turbines to reduce blade erosion. With the extending use of superheated steam, certain set principles of practice are being established. For example, what may be called moderate superheat is being generally settled upon, that is, of from 100 to 150 deg.

Exhaust-steam turbines continue to gain in recognition of their merits. Reciprocating engines in combination with turbines to use their steam through the lower ranges of expansion are the universally accepted means of obtaining the highest steam economy. Many more plants have been added to the number now containing these combination installations and by such arrangements many plants have been enabled to obtain necessary increased capacity without an extension of housing area.

A controversy was initiated by the results of Duchesne's investigation on superheat, when they were given publicity; thus far his findings seem to be questioned by more than give them credence. Briefly his conclusions were that determinations upon superheat in which mercurial thermometers were used were inaccurate; he determined the variation of the specific heat of superheated steam and showed that as the pressure increases all its properties become independent of the pressure and vary only as a function of the temperature. It remains for the authorities to establish the acceptability of Duchesne's results or the older ones.

The study of steam-engine performance received an important aid in the advent of the Clayton method of analyzing indicator diagrams. At the spring meeting of the American Society of Mechanical Engineers, the inventor, J. Paul Clayton, presented a paper indicating that there exists a relation more or less definite between the quality of the steam at cutoff and the exponent of the expansion curve. The exponent is easily determined by the pitch of the curve when reduced to a straight line by reference to logarithmic coördinates. The logarithmic diagram promised a means of determining the leakage into or out of the cylinder, and of the clearance, which promise does not seem to be fulfilled by its application to general work. The paper excited an unusual amount of discussion, which is still in progress.

Early in 1911 the Nordberg Manufacturing Co. built the first American uniflow steam engine and from the extensive tests made upon it developed the type which was put on the market last year. It differs from its German prototype, the Stumpf engine, in having Corliss instead of poppet valves, but obtains the same increased economy through largely reducing the loss due to initial condensation. This engine is remarkable for its great overload capacity and its flat steam-consumption curve and has particular advantages where the load is subject to wide fluctuations. The C. & G. Cooper Co. and the Mesta Machine Co. have also made engines of this type.

As to the progress of that most remarkable of power plants for its overall efficiency, the locomobile, nothing need be said in this review as a very complete article on this subject was given in the last issue.

The indications are that our government has returned to the reciprocating engine as the favored equipment for powering its battleships. Many consider that this decision has been too hastily reached and that the comparisons made between such turbine-driven vessels, as we already have, and those having reciprocating engines, although showing to the disadvantage of the former, should not have been taken so conclusively. The decision seems to have precluded allowance for improvements or modifications that may now be made in turbine installations on the strength of the experience which has been gained. Foreign builders of trans-Atlantic liners continue to equip them with turbines. Probably the two colliers, one to be equipped with reducing gears and the other with electric transmission between the turbine and propellers, will throw some new light on the problem of adjudicating the speed differences between the two ends of the system. Perhaps the most promising solution is to be looked for in a combination of reciprocating engines and turbines.

Among the several advances of moment as affecting the auxiliary equipment of steam-power plants may be mentioned improvement of chain and underfeed stokers to the point where their usefulness is considerably enhanced and their operation made more satisfactory; the application of

kinetic air pumps to surface condensers of large size and their much more general use, and the use of steel becoming the established practice for valves and fittings in steam lines carrying superheated steam.

A sorry muddle has been the only result so far of the attempt to establish a standard for pipe flanges and fittings. The American Society of Mechanical Engineers and the National Association of Master Steam and Hot Water Fitters collaborating proposed a set of specifications to which the manufacturers immediately took exception and brought out one of their own, so that there are now two standards, the United States and the Manufacturers. It is to be hoped that before another year draws to a close there may be a compromise and that one standard will be accepted by all.

Another new departure for American builders is the introduction of turbo-blowers and compressors. A line of these, recently announced by Henry R. Worthington, will be found referred to on other pages of this issue.

The contest between the isolated plant and the central station has continued and it would be hard to say which has gained the most ground. The most hopeful conclusion that can be drawn is that there is a growing disposition to yield the decision in any specific instance to the true engineering claims of either side. Unquestionably there are conditions where the one is decidedly preferable to the other and under such circumstances it is short-sighted to advocate the wrong service: it cannot but work to the later disadvantage of that class of service. Both have their fields and the rapidity of progress of each will be in proportion to the extent to which each confines itself to its legitimate field.

Regrettably, no more states have yet joined with Minnesota, Montana, Massachusetts and Ohio in adopting adequate boiler-inspection and engineers' examination laws. Several states are considering such legislation, and it is very probable that California will be the next to have its name put on the roll of honor, with more soon to follow.

Anent boiler safety, it is fitting to call attention to the new Jacobs-Schupert locomotive firebox. As distinguished from the ordinary radial-stay firebox, this one contains no stays, but, as described in the July 2, 1912, issue, is constructed of U-sections, between which are riveted stay sheets. A remarkable test of the two fireboxes fitted to standard locomotive boilers was made at Coatesville, Penn., last summer. The two were fired under full boiler pressure and the feed-water supply cut off. The radial-stay firebox boiler exploded when the water had fallen to 14½ in. below the crown sheet, but when the water was more than 35 in. below that point in the boiler equipped with the Jacobs-Schupert firebox, it was still intact and the test had to be discontinued when the water had fallen to the point where the evaporation would not keep up the draft. Evidently this year marked the discovery of an explosion-proof locomotive boiler.

Among new hydro-electric propositions is that under way near Pittsburgh. It is estimated that over 100,000 hp. can be developed when the installation is complete. The Keokuk, Iowa, hydro-electric development made considerable progress and during the summer the 7500-kw. generators were completed for the installation. Perhaps the most notable water-power work during the year was that done by the Great Western Power Co., in California, in extension of its present system. When the work now under way at Feather River is finished, this company will have added to its capacity about 600,000 hp., including the completed Big Bend plant, which alone contains four 15,000-hp. units.

Most of the advances in the electrical field during the past year have been in the transmission of power. Improved types of suspension insulators have made it possible to employ voltages heretofore regarded impracticable. Already there is a 140,000-volt transmission line in successful operation in Michigan, and a power development is under construction in California, which will employ 150,000 volts.

Alternating-current practice has not been alone, however, in this tendency toward the employment of higher voltages, for a trolley road has recently been put in service in Montana which operates on 2400-volt direct-current, and 1200-volt lines are becoming quite popular in the Middle West.

As regards generating equipment, the tendency toward larger units was evinced by the installation of 20,000-kw. vertical turbo-generators at the Waterside station of the New York Edison Co., and the Commonwealth Edison Co., of Chicago, has contracted for one of still larger size —a 30,000-kw. horizontal unit. Larger sizes have also spread to rotary converters, some 3000-kw. vertical machines having been installed during the past year. It might also be mentioned that these were the first of this class employing both the synchronous booster and the commutating-pole features.

In the gas-power field the greatest progress during the past year seems to have been in the oil engine. The exceptionally large Diesel engines, advocated so strongly a year or two ago, still appear to be in the experimental stage, but the small- and medium-sized Diesel engines have come to stay, and their use is becoming very general in Europe. A noteworthy event during the past year was the crossing of the Atlantic by the first Diesel liner.

The Junkers engine has also come into some prominence in Germany. While the use of the Diesel engine cannot be said to have spread very much in America, nevertheless, the expiration of the Diesel patents in the United States, during the past year, has been responsible for several engine builders putting out new oil engines, mostly in smaller sizes, and which may be classed as semi-Diesel in type.

Little advance appears to have been made in the large gas engine or gas producer during the past year, and the gas turbine is not as yet a commercial success. A unit expected to develop 1000 hp., built after the designs of Hans Holzwarth by Brown Boveri & Cie., at Mannheim, did not develop the expected power or efficiency, but indicates the direction of future effort.

The large increase in the use of gasoline engines, mostly for automobiles and the ever increasing use of petroleum byproducts, has created such a demand upon the oil market as to practically double the price of fuel oil in this country during the past year, which fact naturally has a tendency to impede the progress of the oil engine.

An event of the year, marking an important step in the advance of the Humphrey gas pump, was the decision, on the part of the Metropolitan Water Board, of London, to install five of these pumps. Four will be of 40,000,000 gal. per day capacity, and the fifth of half that amount. Some even larger units have been designed for the Egyptian Government, one being a pump capable of delivering 100,000,000 gal. per day, with a lift of 19 ft.

These are contemplated for the pumping station at Mex, in Egypt, for extensive irrigation work.

The refrigerating field has been greatly hampered by the difference in various tabulations given by different authorities as to the properties of working fluids used in refrigerating processes. During the year an appropriation was secured from Congress to enable the Bureau of Standards to standardize refrigerating data, and in the past month some noteworthy papers on the properties of ammonia were presented and should result in the adoption of working tables, which may be accepted with some degree of confidence as approximately accurate. There has also been a movement toward standardizing ammonia fittings. Making can ice from raw water is no longer impractical. A number of successful installations were made in 1912, and all indications point toward a rapid advance. From preparations now under way, the Third International Congress, to be held next September in Chicago, should prove a decided success.

One of the new instruments that have become available to the engineer in studying the performance of the equipment under this charge is the Vibragraph. With it, the intensity of vibration, on or near a machine, may be measured, indicating when it is of a serious nature and should be reduced. Modifications of the foundation or the balancing of revolving elements of a machine may then be made and tests repeated until it is found that more desirable conditions are obtained. Somewhat akin is the Detectorphone, which is quite completely described as "a mechanical stethoscope," being an instrument for rendering more audible any noises in piping or running machinery, so that derangements or other wrong conditions may more readily be located.

While the Panama Canal may not seem to have any very direct connection with the power field, its construction has called forth some quite radical applications of power. Now that it is likely to be opened many months ahead of the scheduled time, it will very shortly command attention on account of the provisions in the way of plant that will be necessary for its operation.

A gratifying tendency is the greater disposition to safeguard the lives of operatives and the public in the operation of industrial establishments and service utilities. In fact the humanitarian element is receiving more nearly its just consideration throughout all lines. This is evident not alone in the more extended adoption of safety devices in connection with power generating and power utilizing equipment, but also in efforts to improve the comfort and welfare of those in or surrounding power stations and factories, as by the reduction of the smoke nuisance, improvement of lighting and ventilation, provision of rest rooms, reading rooms, emergency hospitals, and generally more agreeable environment.

Among the men of prominence in the field of power-plant engineering who have passed away during the year just closed were the following, named in the order of their demise: James McBrier, president of the Ball Engine Co.; Richard T. Crane, founder and head of the Crane Co.; John B. Webb, consulting engineer and former professor of mathematics and mechanics at Stevens Institute of Technology; Francis H. Stillman, president of the Watson-Stillman Co.; Louis Delauney-Belleville, celebrated French engineer and inventor and manufacturer of the Belleville boiler; Read Admiral George W. Melville, noted engineer and explorer, past president and honorary member of the American Society of Mechanical Engineers; Dr. Henry W. Spangler, professor of dynamical engineering, University of Pennsylvania; Antonio Pacinotti, professor of physics, University of Pisa (Italy), and inventor of the multi-segmental commutator, distributed winding and toothed armature; Benjamin Guggenheim, president of the International Steam Pump Co., one of those lost on the "Titanic"; Jacob E. Friend, president of the Nordberg Manufacturing Co.; Otto Jahn, chief engineer of the Vilter Manufacturing Co.; Wilbur F. Richardson, principally known for his work in connection with mechanical lubricators; Theodore Albert, president of the William Powell Co.; George R. Babbitt, prominent consulting engineer and engine designer; James J. Waters, well known marine engineer, for years secretary of the Marine Engineers' Benevolent Association; Vaughan Pendred, for many years editor of *The Engineer*, London; Reuben Wells, veteran railroad man and locomotive constructor; Clement A. Griscom, one of the founders and first president of the American Society of Naval Architects and Marine Engineers; George A. Kimball, chief engineer of the Boston Elevated Ry. Co.; Alfred P. Boller, formerly chief engineer of the Manhattan Elevated R.R. and consulting engineer of the Department of Public Parks of New York.

The Prudential Insurance Company's Plant

Few, if any, office-building plants have grown so rapidly and under such exacting circumstances as that of the Prudential Insurance Co., as stated in the description in this issue. The total horsepower in 1890 was approximately fifty, and the plant consisted of only two small boilers and an electric-generating set. In 1900, when four more large buildings were added, completing the group of five, a plant large enough to meet the requirements was installed.

The electrical system of this plant was of the two-wire, 120-volt direct-control type, and served the demands until 1909 when two more large buildings were added to the group. At this stage of development 120-volt service proved too expensive to continue in view of anticipated further growth and the work of remodeling the entire system into a three-wire, 240-volt remote-control system was begun. One can imagine the thoroughness of co-operation necessary among those engaged in the work to make the change without causing a single interruption of service and to also obtain economy in the use of material and equipment.

Problems of a like nature, but not so complex, were met in completing the various pipe-line connections when the new plant was "hooked up" to the old. This work was also accomplished without service interruptions.

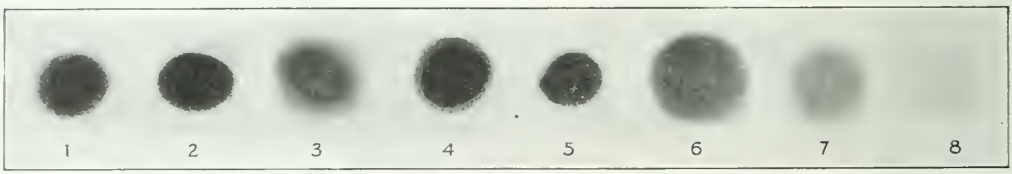
Consulting engineers in particular can appreciate the painstaking care and close study of details required, and the time and skill needed to prepare drawings necessary to successfully carry out the work. Operating engineers will realize the problems that had to be met by the plant engineers during these many additions and alterations, as they not only had to keep the plant going under trying circumstances but had to act as an information bureau for the numerous contractors as well as suggest ways and means of doing the temporary and permanent work so that all chances for service interruptions would be obviated. All this, combined with a general supervision of the installation and the selection of equipment which preceded it, was indeed a big task.

READERS WITH SOMETHING TO SAY

Simple Test for Cylinder Oil

Within certain limits, all lubricating oils look alike. Bearings which can be examined from time to time and watched by means of a thermometer offer the easiest solution for testing lubricants. In the cylinder of an engine it is entirely different. The test naturally must consist of introducing the lubricant and, after the engine has run for a time, examining the cylinder walls. Insufficient lubrication or a lubricant poor in quality are revealed either by "groaning" of the valves or else finding, when examining the cylinder walls, that scoring has begun.

With the view of adopting some simple and comparative means for testing cylinder oils, I have tried the following: From a piece of blotting paper, pieces 3 in. square were cut. Samples from the several cylinder oils to be tested were put in bottles (I use 4-oz. size) and these put into a room where all of them will reach the same temperature of about 70 to 80 deg. This requires 20 min. to half an hour. Three drops of oil of each kind were then put on the center of each piece of blotting paper. Each of these blotting-paper pieces was then put for a quarter of an hour on top of the engine where the metal was flat and at a temperature of approximately 210 deg. After remaining for 15 min., the piece was set aside.



Oil Samples after Being Subjected to Test Temperature

The photograph shows eight samples that had been submitted for consideration. This picture shows more clearly than any descriptive matter the suitability or rather unsuitability of some of these oils for cylinder lubrication. Practically nothing was left of samples Nos. 7 and 8. The same might be said of No. 3. No. 4 was very doubtful and evidently contained a heavy body mixed with some lighter oil. Nos. 2 and 5 were samples from a high-grade well known concern and these can be and were used as a basis of comparison. No. 1 was selected on account of the advantage in price and turned out to be as excellent in its work in the particular engine considered, as No. 2, which was tried under the same conditions.

I might add that when the samples were submitted the salesmen furnished the usual information regarding gravity, flash point and viscosity tests. These were all very much alike for the different samples. It is a fact that several oil makers—one in particular—have a lubricating oil and also an oil unsuited for lubrication, both of which have identical gravity, flash point and viscosity figures. This is mentioned as showing that this information is of little practical value in comparing the quality of several oils.

C. E. Fairbanks.

Providence, R. I.

[If the oil samples contained coloring substances it would seem that this test would not indicate the true nature of the oil.—Editor.]

Thawing Frozen Water Pipes by Electricity

Last winter I was employed by an electric light and power company in eastern Pennsylvania and as the weather was unusually severe, a number of water mains and service pipes throughout the city were frozen. The employees of the water company in thawing the pipes at first would dig open the pipe and thaw it with fire; this was slow and unsuccessful as they could make but a few openings in a day. About this time I suggested that they try electricity, which resulted in a total of twenty-six openings in three days. The following is a brief outline of how it was done:

A 15-kw. transformer was mounted on the back of a one-horse wagon, and an ordinary wooden wash tub filled with salt water was set in the front end; then with the necessary wire and assistance, all was ready for action. The wagon was hauled to where the main was frozen and the primary terminals of the transformer were connected to the 2200-volt city primary lines through fused cutouts. One terminal of the secondary circuit of the transformer was then connected to a fire hydrant and the other to a metal plate of about 10x10 in. Another wire was connected to another fire hydrant, the frozen part of the pipe being between the two hydrants, and also to a similar metal plate to the one used for the second secondary terminal. The current was turned on and the plates immersed in the salt water near the sides of the tub and slowly moved toward the center until they were about an inch apart. The plates were held in this position until the water began to flow through the pipe. After the water first began to flow the current was turned off and the water completed the work. The time taken was never more than one hour in the case of a 10-in. pipe. After this work was completed the connections were broken and the wagon was moved on to the next "freeze."

The wire used should be about No. 10 for the primary

extensions and taps while No. 2 or 4 should be used for the secondary taps. Care should be taken not to fuse the transformer beyond its capacity, as serious injury would result.

Where service pipes are frozen, the secondary terminals should be connected to pipes in adjacent dwellings or stores. Frozen pipes about the power plant or those in factory yards can be readily thawed out in the manner described.

EDWARD C. WILSON.

Raleigh, N. C.

Correcting Turbine Governor Trouble

After starting a new 5000-kw. turbine it was found that it raced badly; in fact, there was a variation of 6 per cent. below and 4 per cent. above the normal speed of 1800 r.p.m. The erector for the turbine builders examined the governor valve, overload valve and tried out several types of balanced relay valves, but was unable to reduce either the vibration of the governor levers or obtain good regulation.

The turbine builders then sent their governor expert to inspect the control mechanisms. He tried two cushioning springs and a new type of piston in the dashpot, and while these devices gave closer regulation and more stability to the governor levers, they did not altogether overcome the vibration. He then shut down the machine to dismantle and thoroughly examine the governing mechanism. One of the governor gears was found to be cut out of true with the bore. The builders furnished a new gear immediately, which was installed and corrected all the trouble.

D. J. O'BRIEN.

Birmingham, Ala.

Flameless Combustion

Under the title of "Flameless and Surface Combustion," Professor Bone has been much heralded as the inventor of something remarkable in the combustion line. The leading engineering papers and newspapers and some of the technical societies have given publicity to his schemes, which are disposed to mislead many who are not especially familiar with such problems. Therefore, I would call attention briefly to certain features which perhaps have been overlooked:

Flameless combustion, as the term is used, is a misnomer. All combustion is flameless. The "combustion" which is accompanied by flames is not combustion at all; it is simply a state which is attempting to arrive at a condition of combustion. The luminosity of a flame is due to the incandescence of free carbon, which has been broken down by heat from a hydro-carbon gas and which maintains its luminous condition for that very short, but indefinite interval preceding its union with oxygen, in the formation of CO_2, or its cooling and its escape as a particle of black soot in smoke. This is illustrated by the burning of anthracite coal, containing a very small amount of hydro-carbons, which burn with very little flame, or by hydrogen, which burns with no flame at all. If Professor Bone had said immediate combustion, it would have been technically accurate.

So far as the feature of surface combustion is concerned, the only significance is that he obtains a good mixture between gas and air by the use of such material as firebrick, etc., which has no influence, whatever, in the way of promoting "surface" combustion, but does perform a service as a mixing device. So really, the whole process as described may be summarized by saying that it is immediate combustion of gas brought about by the agency of a mixing device, and this is all there is to it. Thus, it is apparent that there is nothing new in this much heralded method.

The application of gas to combustion in the case of a steam boiler as illustrated by Professor Bone is impracticable for reasons of cost with respect to forcing the gas through the boiler if for no other reason. The high rate of evaporation may be more easily obtained with a coal fire under ordinary conditions if a high condition of combustion is employed. In fact, the only example of the application of combustion, which in my opinion has any value, is the one in which a crucible is heated by gas which is mixed with air between the pieces of a refractory material such as firebrick surrounding the crucible.

Chicago, Ill.

A. BEMENT.

Turbo-Condenser Problem for Discussion

Will interested readers of POWER tell me what was wrong with our Parsons type steam turbine. It had been set up and run about ten weeks, when suddenly the vacuum fell to 15 in. At this vacuum it would not carry its load of a thousand kilowatts.

The dry-vacuum pump is of the jet type, but would not work. Repairmen worked on it quite a while and finally gave it up. The pipes were all overhauled and cleaned and the pump still refused to work. Then the experts from the turbine company came and spent much time investigating, but with no good results. These men had packed their grips and were ready to start away when they tried the turbine again; it started and worked as it should. It has been running well since except when a mud turtle stopped the intake pipe to the condenser.

It takes about 29.5 in. of vacuum, when the air pressure is 30 in. to carry the thousand kilowatts on the machine.

STANLEY C. ALLEN.

Lansing, Mich.

Friction Loss in Wrought Iron Pipe

In reply to Mr. Kent's criticism on page 868 of the Dec. 10 issue, on my chart for determining the friction head due to the flow of water in pipes, I call attention to the fact that due to a typographical error the ordinate 0.15 was printed 0.1 and the ordinate 0.1 was printed 0. As a matter of fact, when using logarithmic paper in plotting curves it is impossible to reach zero, as may be easily seen by examining a sheet of logarithmic paper. If the top line is taken as 10, then the bottom line is 1. If another sheet is added below, the lowest line is 0.1, on the next sheet 0.01, on the third 0.001, and so on. Substituting the figures given above will correct the discrepancy in the chart.

W. L. DURAND.

Brooklyn, N. Y.

QUESTIONS BEFORE THE HOUSE

Simplifying Indicator Diagram Analysis

Having been interested in the articles in POWER relating to indicator-card analysis, I would offer the following as a more convenient way of finding the value of n in the formula

$$pv^n = c$$

where the engineer is reasonably certain of the correctness of the expansion line.

In the formula, n equals the ratio of the specific heat at constant pressure to the specific heat at constant volume

$$n = \frac{log.\ p_2 - log.\ p_1}{log.\ v_1 - log.\ v_2}$$

where p_1 and p_2, v_1 and v_2 are two different pressures and their corresponding volumes, taken directly from the expansion line of the diagram under consideration.

The proof of this is a simple mathematical one, involving the subtraction of the two logarithmic equations of

$$pv^n = c$$

By using this value of n the weight of steam in the cylinder at cutoff can be found as described in Prof. Clayton's article in POWER for June 18, 1912.

But it is also necessary to know the volume of steam at the beginning of compression, to calculate the steam consumption of the engine. This may be found as follows: By taking any pressure p_3 and its corresponding volume v_3 from the compression line of the diagram, the constant (c) for this line is readily determined, n for the compression line being derived in the same way as for the expansion line. For log. $c = log.\ p_3 + n\ log.\ v_3$. c being known, we may now take a value of p equal to the exhaust pressure of the engine, say p_4. Then the volume of the steam at this pressure, that is, the volume of the steam at the beginning of compression, is found from the formula

$$Log.\ v_4 = \frac{log.\ c - log.\ p_4}{n}$$

c, p_4 and n being known.

The use of this method obviates the necessity of plotting the diagram to logarithmic coördinates every time the engineer desires to find a value of n wherefrom to calculate the steam consumption of his engine.

LLOYD W. TAYLOR.

Grinnell, Iowa.

Steam Gage Problem

On page 799 of the Nov. 26 issue, Mr. Pollard offers a solution of a steam-gage problem. I do not approve of his manner of procedure in correcting defective gages.

In the first place when the gage showed signs of working badly it should have been taken down and tested; and if found wrong and the trouble located in the gears it should have been sent to its manufacturer for repairs, who no doubt would have replaced the worn parts with new ones instead of using the old ones. Then the gage would have been calibrated and returned in first-class condition.

The mechanism of a steam gage is very delicate and the parts are made to work with one another with the least possible lost motion; and when these parts wear enough to form a shoulder, so large as to retard the action of the gage, and are then dressed down with a file, the reading is bound to be inaccurate. And this inaccuracy is unlikely to be uniform throughout the range of registering.

Steam gages are the engineers' guide and are no instruments to be tampered with or experimented on by unskilled hands. Nor is the boiler inspector fitted for this work.

The maximum repair cost to a defective gage, or even the price of a new one, is cheap, when it is known that the instrument can be depended on to register correctly.

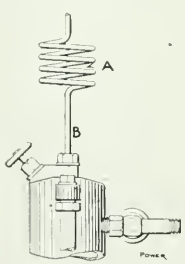
GEORGE B. LONGSTREET.

Somerville, Mass.

Repairs to Lubricator Condenser

Under the above heading in the Oct. 29 issue, Alford H. Smith of Rogers, Ark., describes how he repaired a broken lubricator. The condenser, that pear-shaped bulb affair we usually see attached to hydrostatic lubricators, was broken, so he replaced it with a straight piece of pipe, and the lubricator gave no further trouble.

I have often wondered if these attachments are necessary on lubricators, and have removed some of them in a somewhat similar manner to that employed by Mr. Smith, with satisfactory results.



LUBRICATOR WITH COIL OF PIPE AS CONDENSER

The condensation in 8 or 10 in. of 1/4-in. pipe should be sufficient to operate the lubricator under ordinary conditions. I suppose that the object of this globular condenser is to store a comparatively large quantity of water for use in emergencies, but it has its disadvantages. If the condenser ever gets hot, the lubricator will refuse to start for five or ten minutes, i.e. until two or three ounces of water has accumulated in the condenser.

An engineer not well acquainted with this style of

lubricator is apt to lose patience, and to "monkey" with the valves in his endeavor to locate the trouble. Perhaps the answer to this would be to keep the condenser cool, but we all know that there are occasions when they will become heated. If the lubricator is allowed to become empty of oil the condenser will get hot, as it will also when sometimes steam is allowed to blow through the lubricator to clear it of sediment. When filling the lubricator, care should be taken to fill it to the top. If, for any reason, the oil supply at hand is insufficient to completely fill the reservoir, the balance should be made up with water, otherwise the lubricator will get very hot and refuse to start feeding for quite a while.

The most satisfactory condenser I have used is shown in the sketch. The coil *A* is made of $\frac{1}{8}$-in. iron pipe (brass might be better). It is formed by heating the pipe to a cherry red, and winding a few turns of it around a mandrel, say a piece of $1\frac{1}{2}$-in. pipe. In operation the short length of pipe *B* will fill with condensation in a few seconds, so that there is never any delay in getting the lubricator to start feeding.

B. Copping.

Kankakee, Ill.

Silica in Boiler Water

W. A. Lee brings up a point in the Nov. 19 issue regarding the deleterious effect of silica in the boiler-feed water which is frequently overlooked. In fact, in many of the analyses made to determine the proper chemical treatment of a feed water, the silica is not reported. It must not be inferred, however, that it does no harm. The reason that attention is not more often paid to it is because none of the ordinary softening systems remove it to an appreciable extent. This is not intended as a criticism of softening systems, for it must be said that if the lime and magnesia are properly removed it will not be necessary to get rid of the silica.

It is in untreated water that silica causes trouble. I have analyzed many samples of water and found that the average silica content is 0.95 grain per U. S. gallon. This figure is based on the results of 100 analyses of water taken from all over the United States and Canada. The figures run all the way from an indeterminate quantity to 6.25 grains per gallon which was found in a deep well water in St. Louis. Where the amount is less than one grain per gallon it is improbable that the scale is much affected. When the silica content becomes much greater, however, the scale is apt to be much harder than it would be otherwise.

Just how the silica occurs in water is not known exactly. Silica itself is almost insoluble and it is believed to be present ordinarily in the colloidal form, which is in the region between a true solution and matter in suspension. It will not ordinarily form scale itself but will combine with lime and magnesia scale to form a good imitation of stone. When the other scale-forming impurities are removed any ordinary amount of silica will cause no trouble whatever, particularly if the feed water is very slightly alkaline.

As Mr. Lee says the boiler is no place for chemical reactions to take place, for dense masses of soft scale are precipitated which are likely to collect on the lower sheets and bake and burn out the plates. With much silica present, this is also likely to unite with the soft sludge and make hard scale. Furthermore, the large amount of suspended, precipitated matter floating around in the boiler promotes foaming.

The proper method is to precipitate the lime and magnesia salts outside of the boiler with lime and soda or heat and soda, except in special cases when other chemicals may be preferred. By settling and filtering there is then obtained a clear, soft water, well adapted for boiler feed, or other purposes. When engineers begin to realize this there will be fewer leaky or bagging tubes, hard scale will not be known, corrosion will be done away with, the tendency to foam will be decreased, and all concerned will be satisfied that the investment necessary was well justified.

Edward H. Robie.

Philadelphia, Penn.

How the Valve Deck Was Cracked

Referring to the above communication by John McGinness in the Nov. 26 issue, I wish to say that I had practically the same experience with a duplex fire pump. At the time I decided that it was due to unequal shrinkage of the metal during the cooling of the casting and that later, pressure opened up these shrinkage cracks.

This is evidently what has happened to Mr. McGinness' pump, and the remedy would be to rib the water end longitudinally on the inside and be sure that the cylinder when being cast is made of hard close-grained charcoal iron, and after being cast is left in the sand long enough to cool off thoroughly.

The only other explanation I can give without seeing the actual break is that the valve seats along the lines of fracture were forced in under pretty good pressure and put a strain on the metal which resulted in a crack.

A. Rauch.

Swissvale, Penn.

Painting Boiler Shells to Prevent Pitting

Reading the article in Power under the heading "Zinc Paint as Corrosion Preventive," in the Nov 5 issue, brings to mind troubles I had several years ago with corrosion in 26 water-tube boilers. I tried everything I ever heard of without good results and at last concluded that I must keep the water from coming in contact with the shell plates to overcome this corrosion, which was becoming serious.

I finally hit upon the following plan, which had the desired effect: First I cleaned the shell plates thoroughly with a scraper and a wire brush. Then I painted the plates with paint made of boiled linseed oil and portland cement. When this first coat dried, I put a second coat on composed of one part graphite and three parts cement.

Three years later when I left this plant this very thin scale formed from these coatings was still there and no more pitting had started nor had any of the old "pock marks" grown larger. The graphite added to the second coat keeps the scale from sticking to the paint and, despite the expansion and contraction of the metal, the paint strongly adheres to the plates.

C. H. Liebfield.

Kansas City, Mo.

INQUIRIES OF GENERAL INTEREST

Allowable Load on Stay-bolts

How many pounds per square inch working pressure would be resisted by 1¼-in. diameter stay-bolts 12 threads per inch pitched 6x6 in., the allowable load being 7000 lb. per sq.in. net cross-sectional area?

P. F.

A stay-bolt 1¼ in. in diameter with 12 threads per in. would have a diameter at the bottom of the thread of

$$1\tfrac{1}{4} - (\tfrac{1}{12} \times 1.732) = 1.1057 \text{ in.}$$

hence the net cross-sectional area at the bottom of the thread would be

$$1.1057 \times 1.1057 \times 0.7854 = 0.9602 \text{ sq.in.}$$

and the net allowable load would be $0.9602 \times 7000 = 6721.4$ lb.

The area of the stay-bolt at the bottom of the thread being 0.9602 sq.in., the net area supported by one stay-bolt would be

(6 in. × 6 in.) — 0.9602 sq.in. = 36 — 0.9602 = 35.0398 sq.in.

therefore, the allowable boiler pressure sustained by the stay-bolts would be

$$\frac{6721.4 \text{ lb.}}{35.0398 \text{ sq.in.}} = 191 \text{ lb. per sq.in.}$$

Setting D-slide Valve

How is an ordinary D-slide valve set to get equal lead and equal cutoff and how can the lead and cutoff be varied?

E. D.

The valve will have equal lead and equal cutoff if it has the same amount of lap on both ends when it is in the middle of its travel. To equalize the lap, first lay off the outside edges of the steam ports on the valve seats outside of the valve by pencil lines drawn square across the valve seat, and locate a point half-way between them. Next mark the extreme points of travel of each end of the valve and turn the wheel of the engine so the valve stands in the middle of its travel. The eccentric will then be at the middle of its throw and without moving the wheel the valve is then to be adjusted on the valve stem so it will have the same amount of lap over the steam port at each end of the valve. The valve will then be set for equal lead and equal point of cutoff. Having set the valve central, lead and cutoff can be made earlier by advancing the eccentric on the shaft or both can be made later by setting the eccentric backward on the shaft.

Harmless Fault of Alignment

In lining up a large horizontal engine it is found that the center line of the cylinder, when extended, is approximately $\frac{1}{16}$ in. above the center of the shaft. What effect will such want of alignment have on the strains and general operation of the engine?

H. V.

The strains in the connecting-rod and friction of crosshead, crank and main bearings will be increased but not to any appreciable extent. In general operation this fault of alignment would have no perceptible effect.

Objections to Side Fire Door

What objections may there be to having the fire-door opening for a return-tubular boiler setting in one of the side walls in place of the front wall?

J. M.

The side-wall construction is weakened by such an opening and it should not be employed except possibly with a suspended type of setting. The leading objections in operation are that the radiation and reflection of the furnace heat from the opposite side wall result in considerable loss of heat through the fire-door opening. Unusual heating of the boiler room and inconvenient location of the firing door with respect to the grate and direction of the draft all tend to increase the difficulties of firing skillfully.

Operation of Ammonia Refrigerating System

In what part of a direct-expansion system does expansion of the ammonia take place, and what are the leading conditions for most economical operation of plants of this kind?

P. M.

Expansion of the ammonia takes place in the expansion coils, which are located in the space or room to be cooled. The lower the pressure and temperature in the condensing coils and the higher the pressure and temperature in the expansion coils (i.e., suction pressure), the more economical will be the working of the plant.

Relative Amount of Copper in Two-phase and Three-phase Systems

Why is the copper required for the transmission of a given power by a three-phase, three-wire system only three-quarters of that necessary with two-phase, four-wire systems, the voltage, distance and the line losses being the same in both cases?

H. K.

In the three-phase system let the voltage between wires be E_1, the current in each wire be I_1, and the resistance be r_1. In the two-phase system let these respective quantities be E_2, I_2 and r_2. For simplicity let the three-phase system be delta-connected and the load be nonconductive; then $E_1 = E_2$. The power in the three-phase system $= E_1 I_1 \sqrt{3}$ and in the two-phase system $2 E_2 I_2$. Then

$$E_1 I_1 \sqrt{3} = 2 E_2 I_2$$

whence

$$I_1 \sqrt{3} = 2 I_2$$

or

$$I_1 = \frac{2}{\sqrt{3}} I_2$$

The line losses in the three-phase system are $3 (I^2_1 r_1)$ and in the two-phase system

$$4 (I^2_2 r_2)$$

Therefore, by substituting and equating

$$3 (\tfrac{4}{3} I^2_2 r_1) = 4 (I^2_2 r_2)$$

whence $r_1 = r_2$.

This means that the wires are the same size but as there are three wires in the three-phase system and four in the two-phase system the former requires only three-quarters as much copper.

Most Economical Steam Pressure for Automatic Engine

What would be the relative coal consumption of an automatic engine running with 80 lb. of steam as compared with 40 lb. and the same load?

A. B.

The economy depends on the point of cutting off required in each case as determined by the amount of the load and the size of the engine cylinder.

Rating of Refrigerating Machines

What is the method of rating refrigerating machines?

T. B.

(1) Refrigerating capacity, and (2) ice-making capacity, both expressed in tons per day of 24 hours.

One ton of refrigerating capacity would mean that under assumed or stated conditions, as range of temperature, the machine would remove the number of heat units equivalent to that required to melt one ton of ice at 32 deg. F. into water at 32 deg. F. in 24 hr. In the United States 288,000 B.t.u. per 24 hr. per ton of refrigeration is the recognized figure, being made up of 144 B.t.u. per lb. of ice melted and a ton of 2000 lb. This gives 12,000 B.t.u. per ton per hour and 200 B.t.u. per ton per minute, the temperatures selected through which the machine is supposed to work being 90 deg. F. in the condenser and 0 deg. F. in the expansion coils.

Ice-making capacity is a measure of the actual weight of ice made by a machine (designed for ice making) in tons per 24 hr., assuming the normal conditions of summer weather. It is usually about one-half the refrigerating capacity.

Inside Lap

What is inside lap and what is the object of putting inside lap on a valve?

R. G.

Inside lap or exhaust lap is the amount the exhaust edges of a D-slide valve overlap the exhaust edges of the cylinder ports when the valve is in mid position. In adding sufficient steam lap to bring about good cutoff, the exhaust is apt to be released too early, and exhaust lap is provided to obviate such a defect.

Evidences of Leaky Piston

How would a leaky engine piston be shown on an indicator diagram?

E. J.

A leaky piston would cause the expansion line to fall too low; it would also show too high back pressure of the exhaust while the exhaust valves were open, and would prevent full compression of the exhaust after closure of the exhaust valves.

Lowest Safe Water Line in Horizontal Return-tubular Boilers

Where should the bottom try-cock be placed on a horizontal tubular boiler, in relation to the tubes?

W. R.

The lowest try-cock, the lowest visible part of a water gage-glass and the location for fusible plugs should not be less than 2 in. above the upper surface of the upper row of tubes.

Cause for Fracturing Wristplate Centerpin

What might cause the wristplate-centerpin of a 14x36-in. Corliss engine to break repeatedly? Fracture of the pin occurs in each instance close up to the shoulder.

S. R. B.

Fracture might result from the pin being turned with a sharp corner instead of a fillet at the shoulder; but repeated breaking of pins would seem to indicate that the wristplate becomes jammed by one or more of the valve rods dead-centering with the valve arms, as might happen if the valve-arm keyways have been improperly laid out on the valve stems, or the right-and-left connections between the valves and wristplate have been shortened too much.

ENGINEERS' STUDY COURSE

Cube Root

The cube of a number is the product of a number taken three times as a factor, thus

$$3 \times 3 \times 3 = 27$$

which is the cube of 3.

The cube root of a number is a number which taken three times as a factor will produce that number. In the above example we see that the cube root of 27 is 3.

As we just learned how to find the square root of a number, the process of finding the cube root will come easy. Let it be understood at the beginning that it is so seldom necessary to find the cube root of a number that nearly all who have learned how must refresh their memory each time they are required to do an example in cube root. We will explain the process of finding cube root by the long method, and learn how to find the cube root by the use of a table.

In square root we point off the number into periods of two places each, but in cube root a period consists of three figures. We begin to point off at units place; to the left of the decimal point for whole numbers and to the right for decimals, just as we did in our square-root lesson. As in square root so in cube root, the number of periods indicates the number of figures there will be in the root.

In our square-root lesson we learned that when a number was not a perfect square and we wanted to carry the root out to decimals we had to annex a period of two ciphers each for every decimal place added to the root. The same is true of cube root, except that a period of three ciphers is added for every added decimal place.

Example: What is the cube root of 79,507?

For convenience a table of cubes from 1 to 9 is given below.

$1^3 = 1$	$4^3 = 64$	$7^3 = 343$
$2^3 = 8$	$5^3 = 125$	$8^3 = 512$
$3^3 = 27$	$6^3 = 216$	$9^3 = 729$

```
                                  root
 4                    79 507 )43 ans.
 4                      64
1600 × 3 = 4800       15 507
                      15 507
   4
   3
 120 × 3 = 360
       9
  5169
    23
 15,507
```

Pointing off, we have two periods, so we know there will be two figures in the root. Now we find the greatest number the cube of which does not exceed 79. This is obviously 4, and the cube of 4 is 64 which is put under the first period 79, and subtracted, giving a remainder of 15. Now bring down the next period, getting a dividend of 15,507.

To get a new trial divisor we set down at the left the 4 in the root and square it, getting 16, to which we add two ciphers. We now multiply 1600 by 3 getting 4800 which is our new trial divisor and indicates a quotient of 3. The next step is to multiply the first figure of the root by the second figure which is 3, and add a cipher to the product. This gives us

$$4 \times 3 = 12$$

and the cipher added equals 120, which must be multiplied by 3, giving 360. (We used 3 as a multiplier of 1600 and 120, not because it is the second figure of the root, but because 3 is used as a constant at this point of the process in all cube root examples.)

Set this 360 under the 4800 then square the second figure of the root getting 9, which we set down under the 360. Now add the column of figures, which gives

$$4800 + 360 + 9 = 5169$$

which is the complete divisor and must be multiplied by the second figure of the root or 3. The product equals the dividend, leaving no remainder which shows that 79,507 is a perfect cube.

Let us take another example that will contain three figures in the root so as to show how the trial divisors are obtained when there are more than two figures in the root.

Example: Find the cube root of 669,921,875.

```
                                   root
 8                    669 921 875 ) 875 ans.
 8                      512
6400 × 3 = 19,200     157 921
                      146 503
   8                   11 418 875
   7                   11 418 875
 560 × 3 = 1,680
          49
      20,929
           7
     146,503
  87
  87
 609
696
756,900 × 3 = 2,270,700
     87
      5
  4350 × 3 = 13,050
         25
   2,283,775
           5
  11,418,875
```

From what was learned in the previous example, the process in the above example is plain up until it is necessary to find a trial divisor for the third dividend which is 11,418,875. To get this trial divisor we combine the two figures of the root already obtained and square them,

$$87^2 = 7569,$$

and then we annex two ciphers and multiply by 3. This gives us

$$756,900 \times 3 = 2,270,700$$

which is our trial divisor. We find that it will go into

the dividend 5 times, so write 5 as the third figure of the root. Now combine the two first figures of the root and multiply by the third figure

$$87 \times 5 = 435$$

and annex a cipher to the product, giving 4350.

This is now multiplied by 3 which gives 13,050 and is set down under the 2,270,700. Next square the third figure of the root, getting 25 and set it down under the 13,050. Now add the column

$$\begin{array}{r} 2{,}270{,}700 \\ 13{,}050 \\ 25 \\ \hline 2{,}283{,}775 \end{array}$$

which is the complete divisor for the dividend 11,418,875. As the divisor is contained in the dividend 5 times without a remainder the number is a perfect cube.

To prove examples in cube root use the root three times as a factor. Thus to prove our first example,

$$43 \times 43 \times 43 = 79{,}507.$$

If at any time it is found that the product of the complete divisor by the trial figure of the root exceeds the dividend it will be necessary to corfect the work to conform to the next lowest trial figure in the root. If ever the dividend is less than the trial divisor, place a cipher in the root, bring down another period, annex two ciphers to the trial divisor and proceed as before.

By this time we have learned that the process of finding the cube root of a number is very laborious and we can therefore, appreciate the value of a table that will tell at a glance just what is the cube and cube root of a number, and of course, which also gives the number when the root is known.

Nearly all engineers' hand- and pocketbooks contain tables giving the squares, square root, cubes and cube roots of numbers from 0.1 to 1000 and over. Kent's Mechanical Engineers' Pocketbook gives numbers from 0.1 to 1600. In this book the numbers from 0.1 to 10 increase by tenths, and all numbers from 10 to 1600 increase by 1.

Parts of this table are given below so the reader may more fully appreciate the value of such tables.

No.	Square	Cube	Sq.Root	Cube Root
6	36	216	7746	8434
65	4225	2746	8062	8662
7	49	343	8367	8879
75	5625	4219	8660	9086
8	64	512	8944	9283
2	4	8	1 4142	1 2599
1	4 41	9 261	1 449	1 281
2	4 84	10 648	1 483	1 301
3	5 29	12 167	1 517	1 320
4	5 76	13 824	1 549	1 339
5	6 25	15 625	1 581	1 357

No.	Square	Cube	Sq.Root	Cube Root
210	44100	9261000	14 4914	5 9439
211	44521	9393931	14 5258	5 9533
212	44944	9528128	14 5602	5 9627
213	45369	9663597	14 5945	5 9721
214	45796	9800344	14 6287	5 9814

The reader should occasionally do examples in cube root so that should he be called on to find the cube root of a number when a table was not available or when the cube root could not be found from a table he would not be "stuck."

Examples for Practice

1. What is the number of which 9,393,931 is the cube?

2. Find the cube roots of the following numbers: (a) 0.8; (b) 2.5; (c) 213.

3. What is the number of which 44 is the cube root?

4. The diameter of a sphere is found by dividing its cubical contents by 0.5236 and extracting the cube root of the quotient.

It is desired to make a cast-iron ball to weigh 364 lb. Cast iron weighs 0.26 lb. per cu.in. What would be the required diameter?

5. D. K. Clark gives as a rule to find the diameter of a shaft capable, within good working limits, of transmitting a given horsepower:

Multiply the horsepower by 385 for cast iron, by 190 for wrought iron and by 92 for steel; divide by the speed in turns per minute. The cube root of the quotient will be the diameter in inches.

According to this rule what would be the diameter of a steel shaft required to transmit 20 hp. at 200 r.p.m.?

Answers to Last Week's Problems

(1) (a) 3.285; (b) 18.06; (c) 0.028; (d) 3899.
(2) (a) 2.6458; (b) 3.60556.
(3) 42 ft.
(4) 85 in.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"FOREWORD"

It's plain to you upon its face
That Power's need for much more space
Has driven us to serve these "spills"
In capsule doses for your ills.
So when a joke's not over-ripe
We'll put it here in "six-point" type.

Our friends the marine engineers have fittingly chosen German Artillery Hall in which to hold their festivities during the Charleston convention. Let each doughty warrior gird himself for the fray, be served with abundant "ammunition," and be placed where the "shots" fall the thickest. Charleston this day expects every man to do his duty. The watchword will be Prosit!

Catherine Morris, of Pittsburgh, attired in men's clothes, worked in boiler and machine shops for three years before anybody discovered she was just Cathy. During this time she demonstrated she was some white hope by licking a shopmate in a fist fight, and she has a scar on her face to prove it. From all this, one is assured that while Cath is not what could truthfully be called a perfect gentleman, she's a real manly young lady, just the same.

It was a happy new year's beginning for a few electricians and boilermakers at the New York navy yard. The master electrician now gets $9.04 a day instead of $8, and the master boiler maker $7.04 instead of $6.24. Now, boys, remember your home obligations and don't hold out on those few odd cents.

Yes, Ignatius, dirt in a governor does operate against its efficiency. As a case in point, Cole Blease, a very soiled governor of good old South C'rlina, attempted to start something the other day by consigning the Constitution to Hades, along with everybody else who had the temerity to disagree with him. They used to call him "Coley" in the old days; what they call him now isn't fit to print.

We are pleased to receive a circular from Greenwood's woodyard, Woodsville, N. H., announcing "mixed wood at $3 a load. This wood can be seen at Mr. Long's brick yard. Carrying upstairs, 35c. extra." Any Woodsville man who gets a $3 load may be lucky, but if he's inclined to throw things he should keep away from Mr. Lang's brickyard. Charging 35c. for carrying a load upstairs seems a trifle excessive. Many a load has been thrown down stairs free of charge, and the distance up is no greater.

Wish we could put J. Sharshall Grarsty in our Hall of Fame, but he's not an operating engineer; just a Ph.D., a scholar, a gentleman and an editor of "The Tradesman," of Chattanooga, Tenn. The loss is ours, doctor, but we are respectfully curious to know if the "J" might stand for Jiphthahel or Jonadab? Of course, it might, but does it?

Central Station vs. Isolated Plant

By Warren B. Lewis

Arguments in the case of the central station vs. the isolated plant, seem to be never-ending; now a new proposition is a summer central station and a winter isolated plant.

Unfortunately little has been brought to light relative to this phase of generating electrical energy, but a few facts are herewith presented concerning a typical office building, which may serve to center the argument on something definite. It would be interesting to know wherein other office buildings differ in their general requirements.

The building is ten stories high and of modern fireproof construction. It covers a ground area of approximately 20,000 sq.ft. For several years it has been purchasing central-station current, but operating its own hydraulic elevator steam pumps, and heating with direct-steam radiation. The owners proposed installing a plant for lighting purposes.

A careful investigation showed that the maximum demand during daylight office hours was about 20 kw., chiefly in the form of elevator lighting and a small amount of corridor lighting. The maximum energy at 5 o'clock in the afternoon of a winter day was 150 kw. Current is metered to all the tenants. The total energy purchased from the central station had averaged for three years, 50,000 kw.-hr. per year.

Here were definite conditions to be met, with a record of the cost of operation under the existing conditions. Bids were taken for a plant consisting of one 25-kw. unit and two 100-kw. units, on the theory that the small unit would take care of the day lighting, and should one of the large units be out of service, the maximum peak load could be carried on the other large one and the small unit. It was found that the cost of the plant, when completely installed, would be approximately $20,000. A number of small items could only be estimated; but the figure given represented the sum total of all the material and labor which would enter into the installation of the plant.

Allowing 5 per cent. for interest, 5 per cent. for depreciation, and 2 per cent. for repairs, there would be a fixed charge of $2,400 per year, which, divided by 50,000, gave a cost of 4.8 cents per kw.-hr. for fixed charges alone. At this point it seemed rather unnecessary to pursue the investigation any further, as current was being purchased for but slightly more than this amount.

It may be claimed that the maximum capacity of the plant was out of proportion to the total energy used; but it should be remembered that the tenant who buys metered current is apt to be careful in the use of light, and the load factor of such a plant would be exceedingly small. In fact, the amount of energy used during daylight hours, while not exceeding a maximum demand of 20 kw. was in the aggregate, fully half of the total energy purchased. The total time over which the peak load exists is hardly 300 hr. a year.

Statements that exhaust steam is a great factor in lessening the cost of power, can be easily over-emphasized; for example, it is seldom that, in this plant, enough exhaust steam would be available when heat was wanted. The day load would not furnish enough exhaust steam to heat the building, and during the hours of the peak load the exhaust steam would not be required as the building would be already warm.

In one instance an isolated plant was operated with a day load nearly half of the peak load and their isolated plant appeared to be a good investment. It developed that tenants paid for lights on the basis of a flat rate, with the result that a great many unnecessary lamps were burning all day. That building is now using central-station current, metering the current to all tenants, and the day load has decreased to a mere fraction of what it was before.

NEW PUBLICATIONS

THE STEAM ENGINE AND TURBINE. By Prof. R. H. C. Heck. Published by D. Van Nostrand & Co., New York. Cloth; 631 pages, 5¾x9¼ in.; 402 illustrations; charts; tables. Price, $5.

This is a textbook for engineering colleges and assumes that the student has an elementary knowledge of physics and mathematics. The object of the book is to give the student a knowledge of the theory and general construction of steam motors, no attempt being made to teach either design or operation.

In the first part of the book, the theory of the heat engine, properties of steam and the ideal engine cycles are discussed. Indicator diagrams are then taken up and methods of interpreting them shown. Engine efficiencies are defined and illustrated by numerous examples. Diagrams are given of the various forces in the engine and the construction of its principal parts. Standard types of valve-gears and governors are described, their construction illustrated by diagrams and their functions explained.

The steam turbine is taken up, jet action discussed and tables of turbine performance given. The designs of several types of turbines are explained, numerous illustrations given of the various types and the construction of their working parts.

The book is concluded by a chapter on steam jet blowers, injectors, condensers and other forms of auxiliary apparatus.

Steam tables based on the same data as those of Marks and Davis are given in the appendix.

Three tables of efficiencies, engine, turbine and condenser, are included in the text, which are well worked up and quite valuable. The arrangement of these tables is unusual to say the least, and the peculiar nomenclature necessitates considerable labor in their use. It is unfortunate that books intended for use in schools should not use as far as possible standard symbols.

AN INTRODUCTORY TO THE STUDY OF FUEL. By F. J. Brislee, D. Sc. D. Van Nostrand Co., New York City. Cloth; 269 pages; 6x9 in.; 61 illustrations. Price, $3.

This book is the first of a series of volumes treating the subject of industrial chemistry under the general title "Outlines of Industrial Chemistry." The purpose of each volume is "to provide students and persons employed on the technical side of any particular industry with a handbook explaining the chemical aspect of the operations carried on in that industry." If the others of the series are like the present volume they will be found interesting to those engaged in the business end of the industries to which they relate because only an elementary knowledge of chemistry is necessary to understand most of the subjects treated.

The first two chapters treat of the chemistry of combustion and include a consideration of reacting substances, reaction velocity and the use of catalysers to accelerate the velocity of reactions. The next chapter deals with the analysis of fuel and flue gases and proves very instructive. Directions are given for the use of Hempel, Orsat and Stead apparatus. The precautions to be observed in taking and analyzing a flue-gas sample are enumerated.

Calorimetry is the subject of Chapter IV and includes instructions for using several well known calorimeters. Chapter V describes the many kinds of pyrometers for furnace control, and special attention is given to the Féry radiation pyrometer.

After a rather technical discussion of combustion temperature calculations in Chapter VI, the classification and composition of various fuels are treated. A simple laboratory test is described for identifying the class to which a coal belongs, i.e., as to whether it is a caking or noncaking coal.

Another chapter treats the subject of coke, coke making and the recovery of the byproducts. A few types of coke ovens are described and the commercial value of briquetted coal is discussed.

The composition of natural gas, and the composition and commercial combustion of producer, water and blast-furnace gas are also covered and a chapter on the chemistry of rapid combustion or explosion contains an instructive explanation of the combustion of fuels and heat losses in explosion motors.

The last four chapters treat of "Air Supply and Measurement of Draft," "Furnace Efficiency and Fuel Economy," "Heat Balances, Furnace and Boiler Tests" and "Liquid Fuels," and are particularly useful to the power-plant engineer.

The author recommends the purchase of coal upon the basis of its heating value, and then proceeds to point out the fallacy of the objections raised against this practice. He believes that coal samples are not selected with sufficient care to be truly representative of the total quantity and that this is the chief reason for the prejudice so prevalent against this system of purchase.

The University of Illinois has issued a revision of bulletin No. 9, dealing with "An Extension of the Dewey Decimal System of Classification Applied to the Engineering Industry," by Professors L. P. Breckenridge and D. A. Goodenough. This may be obtained by addressing the Engineering Experiment Station, Urbana, Ill. Price, 50 cents.

Nine Men Killed in Hamlet, N. C., Boiler Explosion

As the result of the explosion of a stationary boiler in the Seaboard Air Line Ry. shops, at Hamlet, N. C., on Dec 28, according to press reports, nine men were killed including the roundhouse foreman, the assistant foreman and an electrician.

One part of the boiler was hurled through an 18-in. wall and thrown 500 ft. away. The body of one of the negroes employees was found over 200 ft. from the building. No reasonable cause is given, but we hope to publish the details in an early issue.

Special Engineering Lecture Course at Stevens Institute

A special lecture course on engineering topics has been introduced as a regular part of the curriculm for the students of the senior class, Stevens Institute of Technology. These lectures are delivered by well known men actively engaged in the work of which they speak. Some of the lectures and subjects for the first half of the senior year are:

John Calder, of the Cadillac Motor Co., six lectures on shop management, including organization, system, foremen and workmen, industrial hygiene, the modern plant, and the engineer's social relations.

Dr. D. S. Jacobus, advisory engineer, Babcock & Wilcox Co., formerly professor of experimental engineering at Stevens Institute of Technology, two lectures on boilers and power plants.

Henry C. Meyer, Jr., consulting mechanical engineer, New York City, two lectures on heating and ventilating.

Walter Kidde, engineer constructor, New York City, a lecture on power plants for manufacturing and other establishments.

Another course of lectures on engineering topics is now being arranged for the second half of the senior year.

The American Society of Mechanical Engineers has received an inquiry from the Milwaukee Engineering Society with respect to affiliation. Vice-president George M. Brill was appointed to extend the society's greeting to the Milwaukee organization.

W. R. Griffin, general manager of the Tri-State Railway & Electric Co., announces that his concern will build a $2,000,000 power house on a site near Midland, Penn. The company has obtained control of coal mines near at hand for fuel. The J. G. White Engineering Co., New York, will have charge of the work.

The Goulds Mfg. Co., Seneca Falls, N. Y., announces that the Mine & Smelter Supply Co., Denver, Colo., has been appointed as agent for the Goulds line of triplex power pumps. Its territory will include the entire state of Colorado and adjacent counties in Wyoming, New Mexico, South Dakota and Montana.

Annual Meeting of the Efficiency Society

The annual meeting of the Efficiency Society will be convened on Monday, Jan. 27, at 9:30 a.m., in the Engineering Societies Building, 39 West Thirty-ninth St., New York City. The following tentative program has been outlined:

Monday, Jan. 27

9:30 a.m. President's address.
Business meeting.
Election of directors.
10:30 a.m. Symposium on organization.
Discussion on the necessity of charts of organization.
1:00 p.m. Adjournment for luncheon.
2:00 p.m. Symposium on management.
Discussion on democracy in industry and "securing the consent of the governed."
5:00 p.m. Adjournment.
7:00 p.m. Dinner at the Aldine Club, 200 Fifth Ave.
8:30 p.m. Symposium on efficiency in the Government organization, national, state and municipal.
Discussion on a readjustment of the governmental departments.
10:30 p.m. Adjournment.

Tuesday, Jan. 28

10:00 a.m. Symposium on industrial relations.
Discussion on the relations between employer, employee and the community.
1:00 p.m. Adjournment for luncheon.
2:00 p.m. Symposium on industrial hygiene and safeguards against occupational disease and accident.
3:30 p.m. Symposium on safety.
(1) In marine transportation.
(2) In land transportation.
(3) In crowded buildings.
(4) From city conflagrations.
(5) From forest fires.
(6) In mines
(7) In dam protected districts.
(8) From freshet floods.

This session will be illustrated by moving pictures and lantern slides demonstrating the efficiency obtained by conserving the human element in industry.
5:00 p.m. Closing business session.
5:30 p.m. Final adjournment.

SOCIETY NOTES

The Detroit Engineering Society will, at its regular meeting, Jan. 17, at the Employers Association Rooms, Stevens Bldg., Detroit, discuss the subject, "The Pennsylvania Terminal, New York City," by H. O. Pond, of Westinghouse, Church, Kerr & Co., New York City.

The annual banquet of the Ithaca section of the American Institute of Electrical Engineers will be held in Sibley Dome, Cornell University, on the evening of Jan 11. The principal speaker of the evening will probably be R. D. Mershon, president of the American Institute of Electrical Engineers, of New York City. The program will include several several musical numbers and song hits on members of the faculty.

PERSONALS

William Stanley, Great Barrington, Mass., has been awarded the fourth Edison medal "for meritorious achievement in invention and development of alternating-current systems and apparatus."

OBITUARY

GEORGE BURNHAM

George Burnham, Sr., Philadelphia, Penn., formerly a partner in Burnham, Williams & Co., Baldwin Locomotive Works, and an associate of Matthias W. Baldwin, the founder of the works, died Dec. 10, aged 95 years. Mr. Burnham became identified with the Baldwin Works in the early days of locomotive building, and in 1867, following the death of Mr. Baldwin, became a member of the firm, then styled M. Baird & Co. On Mr. Baird's retirement, in 1873, Mr. Burnham became senior member of the firm then known as Burnham, Parry, Williams & Co., and later as Burnham, Williams & Co., which continued until the incorporation of the business in 1909 as the Baldwin Locomotive Works. Mr. Burnham's connection with the industry covered 73 years. He was born at Springfield, Mass., and when about 15 years of age went to Philadelphia. He leaves two sons and a daughter.

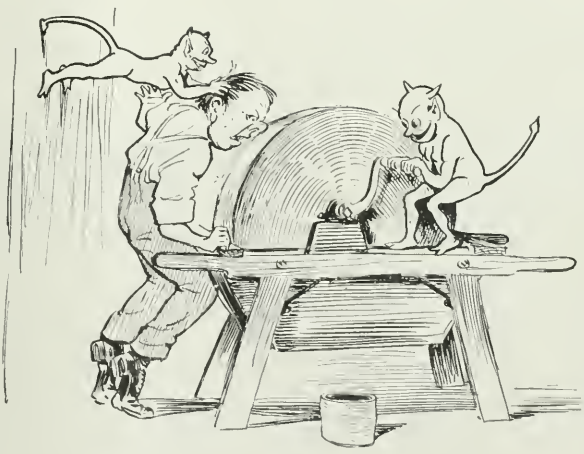
POWER

Vol. 37 JANUARY 14, 1913 No. 2

Beware the Imp of Indolence!

AFTER the novelty of the new job wears off, nothing makes the engineer's life one dreary monotonous daily grind like the Imp of Indolence. The first thing an engineer knows, he is overpowered by the Imp and has his nose to the grindstone.

Many laymen have an idea that the life of an engineer is one of ease, with nothing to do but watch the wheels turn. This apparent visible evidence that the engineer's life is a "snap," leads many young men into the profession who realize in the course of years that it requires time and study to keep up with the procession, let alone get ahead of it so as to put himself in line for something better when the opportunity comes.



So day after day, and day after day, these misguided novices perform the same routine work in a plant where there is every opportunity to make a record for performance; they overlook the all-important fact that to achieve any measure of success they must know not only what has been done in the past, but they must keep posted as to what is being done now in the line of the generation and transmission of power.

Surrounded almost and certainly within easy reach of an abundance of excellent and authentic reading matter to relieve their difficulties, they keep on in the same old way, day by day, with their noses to the grindstone, heedless of the available literature to lighten their burden.

There are many men also who take trade papers and own books relating to power plant subjects, but who never take the time to glance at their valuable contents. These engineers are no better off than those who do not subscribe for engineering journals at all, and who do not own so much as a book on power generation.

Don't let the Imp of Indolence keep your nose to the grindstone. Break away from his grasp; then reading and studying will lead the way to success where the monotonous daily grind is replaced by a position wherein executive ability is required and where one has a larger field in which to develop himself and show his worth.

[*Contributed by George H. Wallace, Racine, Wis.*]

New Perth Amboy Central Station

By Warren O. Rogers

SYNOPSIS—Description of a new central station having many features worthy of notice. The method employed in cutting in and out turbines and exciters by illuminated signals is one of them.

The Public Service Corporation of New Jersey controls three distinct enterprises, the Public Service Gas Co., the Public Service Railway Co., and the Public Service Electric Co. The last is divided into three divisions, known as the Northern, Central and Southern, each operated under a separate management. The Perth Amboy station is in the central division and works in conjunction with the seven other generating stations of that division. In Fig. 1 is shown the relative location of stations and substations. The main circuits are all of 13,200 volts and the load is composed of power, lighting and street-railway service.

The station has been built on the west bank of the Arthur Kill, which facilitates the delivery of coal by water and also affords an abundant supply of salt water for condensing purposes. Fig. 2 shows a view of the station from the water front at low tide, also the conveyor runway and condensing-water intake.

The building is constructed of red brick with terra-cotta trimmings. It is divided into a boiler and a turbine room, each having a large, well lighted basement. The turbine room has a gallery at one end where the engineers' offices are located. It is built with a temporary wall to permit of extending the building eventually.

The inside walls are yellow pressed brick. The turbine-room floor is concrete with gratings between the turbine-room floor upon which the field generator switches and circuit-breakers are mounted.

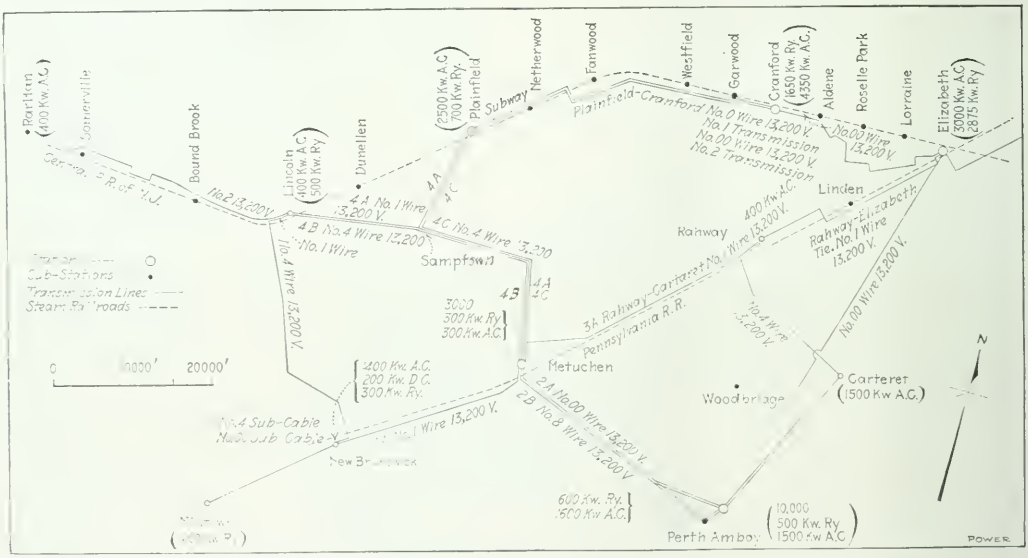


Fig. 1. Showing Relative Location of Power Plants and Substations of the Southern Division of the Public Service Co.

The boilers are constructed of red brick with terra-cotta trimmings. It is divided into a boiler and a turbine room, each having a large, well lighted basement. The turbine room has a gallery at one end where the engineers' offices are located. It is built with a temporary wall to permit of extending the building eventually.

The inside walls are yellow pressed brick. The turbine-room floor is concrete with gratings between the

Turbines and Exciters

There are two double-flow turbines which run at 1800 r.p.m., each driving a 5000-kv.-a., three-phase, 60-cycle alternating-current generator with a voltage of 13,200. These machines are set crosswise of the turbine room as in Fig. 3, on a foundation of steel piers inclosed in concrete, shown in Fig. 10. The governor oil pressure is maintained at 44 lb. and that on the bearings at 5½ lb. The machines are fitted with a tachometer. Two auxiliary bearing oil pumps are used when starting and stopping. Each generator has an individual slate switchboard on the

Three turbine-driven exciter sets are placed in a bay at the head of the turbines, Fig. 4. The generators are of 800 amperes capacity at 125 volts, with a speed of 2400 r.p.m.

Heaters and Recording Instruments

At the other end of the same bay are two open feed-water heaters, using the exhaust steam from the auxiliary units about the plant.

On the wall behind the heaters is located the recording instrument board, containing two recorders for feed wa-

ter temperature, two for vacuum, one for steam pressure and one for steam temperature. There are also two venturi-meters, recording and indicating the quantity of water used in the boilers.

Boiler Room

In the boiler room, which is separated from the turbine room by a brick wall, the entrance through which is protected by fireproof metal doors, are eight 600-hp. water-tube boilers fitted with superheaters. Each boiler has 294 tubes, 18 ft. long, and three 42-in. drums, 20 ft. 4 in. long. A view through the firing alley between the four batteries of boiler is shown in Fig. 5.

Fig. 2. Waterfront View of the Station, Showing Coal-conveyor Runway and Condenser Intake

Coal is delivered to the 1500-ton capacity concrete coal bunker, above the boilers, by a 400-ft. belt conveyor, running from the wharf to the power plant through a runway, as shown in Fig. 2. From the storage bin the coal runs through spouts, each fitted with a weighing scale and into the stoker hopper as wanted. All charges weigh 1600 lb. and tally is kept by the fireman on a registering clock each time a new charge is weighed. The register is checked at the end of every shift. The coal is unloaded from barges by a clamshell bucket, operated by a steam hoisting engine, and dumped into a hopper above a coal crusher operated by a 10-hp. induction motor. The belt conveyor is operated by a 30-hp. induction motor.

A view of the back of the boiler setting is shown in Fig. 7. Each of the 24 blowoff pipes contains a plug cock and a blowoff valve of the gate type. The smoke uptake from each boiler connects with a separate main smoke flue, running along the rear and above each row of boilers to the two brick chimneys.

The draft of each battery of boilers is controlled by a damper regulator. If the plant is running with a light load with only a small part of the boiler capacity under steam, hand regulation is adopted, as there is sufficient natural draft for eight boilers on each chimney. With full boiler load forced draft is used, each set of four boilers being served by a 10-ft. fan driven by a 12x14-in. engine. These units are set, one under each stack between the four steel and concrete columns which support the chimney, as shown in Fig. 6. Air is carried to the furnaces through a sheet-iron air duct, supported by the basement ceiling, branches going to each furnace. These chimneys, contrary to the general practice of using a solid foundation, set on four steel columns incased in concrete, upon which I-beams are set and which support a concrete base, Fig. 6. The chimneys are 179 ft. high and 14 ft. in diameter at the top. Both chimneys are at the end of the boiler room having the temporary end-wall construction, but the doubling of the boiler installation will make them central in the boiler room, the duplicate smoke flues entering from opposite sides of the stack.

Refuse from the ashpit is loaded into an ash car in the basement, as shown in Fig. 8, and at present is removed to the yard and used for filling-in purposes. The stoker

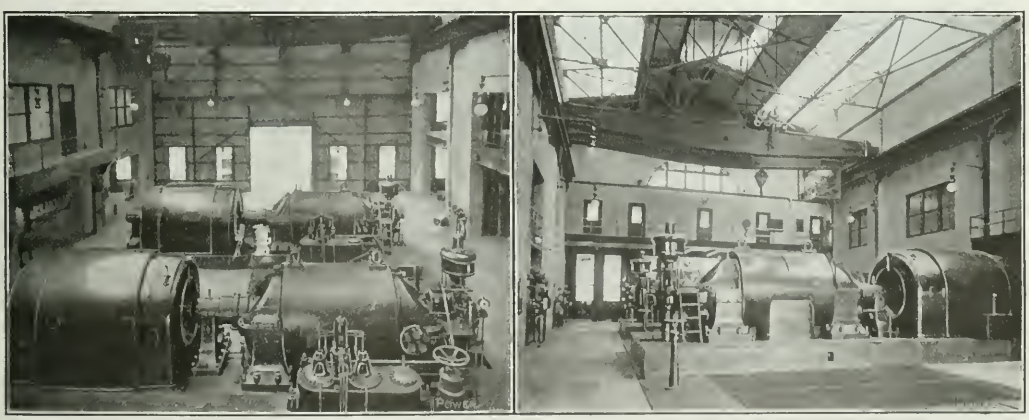


Fig. 3. Two Views of the Turbine Room of the Perth Amboy Station

shafts are motor driven, but a vertical steam engine is also installed for each and connected to the stoker eccentric shaft by a belt and clutch. The stokers are operated from the shaft eccentrics by an eccentric-rod. The two shafts and the motor which drives them are hung from the basement ceiling.

Feed-water Pumps

Water is supplied to the boiler by three 80-hp. steam-turbine-driven centrifugal pumps, running at 2400

r.p.m. These are in the basement, under the feed-water heaters, which are on the floor above.

Two 6 and 4 by 6-in. duplex oil pumps handle the oil from the two filters. The house water supply is handled by one of two 10 and 6 by 12-in., outside-packed, duplex pumps, pot-valve type. On the same floor is an 18 and 10 by 12-in. underwriters fire pump with a capacity of 1000 gal. at 70 r.p.m. A view of the pump room, with the turbine-driven centrifugal pumps in the distance, is shown in Fig. 9.

A 9 and 10 by 12-in. steam-driven air compressor furnishes compressed air for plant use and is placed at one end of the basement where a plant machine shop has also been installed.

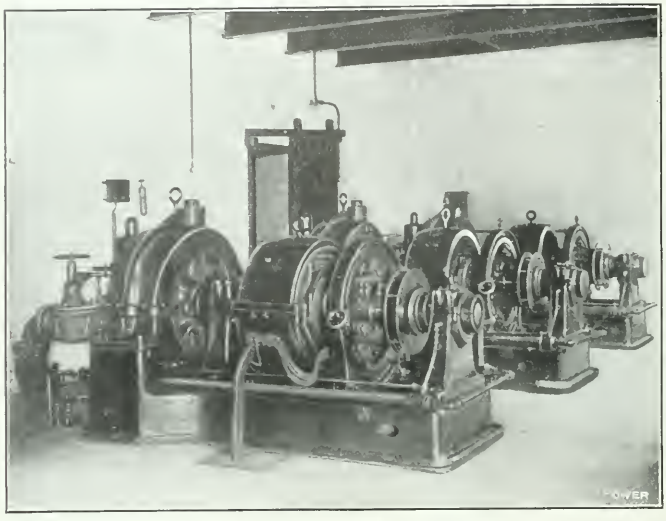


FIG. 4. STEAM TURBINE-DRIVEN EXCITER UNITS

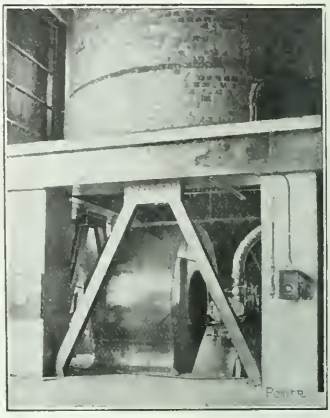


FIG. 6. FORCED-DRAFT FAN, CHIMNEY AND FOUNDATION

CONDENSERS

Two surface condensers, each containing 10,000 sq.ft. of cooling surface, are in the basement, one directly under each turbine. Each condenser is served by a 12 and 22 by 18-in. rotative dry-air and vacuum pump and a circulating unit consisting of a 20-in. three-impeller centrifugal pump directly connected to a 36-in. steam turbine; the hotwell pump is 4 in., directly connected to a

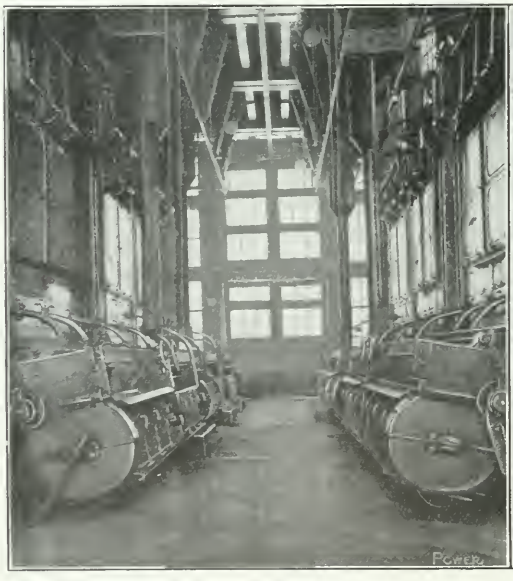


FIG. 5. VIEW THROUGH FIRING ALLEY

FIG. 7. BLOWOFF PIPES AND SMOKE UPTAKES

steam turbine. A feature of their installation that should appeal to engineers is that both condenser units are placed between the four concrete-supporting piers, as shown in Figs. 10 and 11, thus occupying a minimum of floor area other than that occupied by the turbine foundations.

Each circulating pump takes water from two lines of 6-ft. concrete intake pipe which run from a point beneath the plant to a natural forebay outside of the plant. There is also a 10-ft. concrete circulating water-discharge canal. Each equipment is guaranteed to condense 75,000 lb. of steam per hour and produce a vacuum of 28 in. with circulating water at 70 deg. F., or 28½ in. vacuum with the circulating water at 60 deg. F.

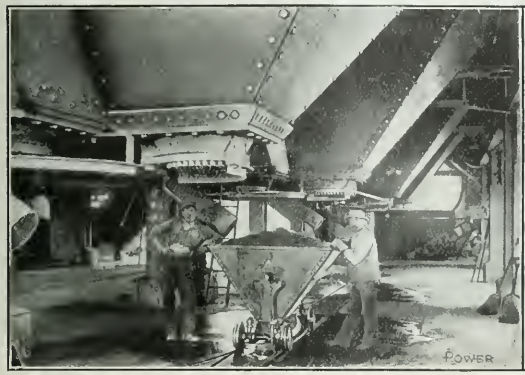


FIG. 8. METHOD OF HANDLING ASHES

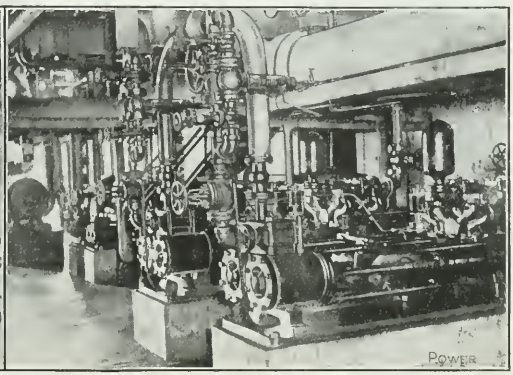


FIG. 9. VIEW OF THE PUMP ROOM

ELECTRICAL APPARATUS

In addition to the turbo-generators and exciters, the station is equipped with one 1000-kv.-a. oil-immersed, water-cooled transformer and one 500-kv.-a. oil-cooled transformer for supplying local service at 2100 volts, two-phase. There is also one 500-kw. 60-cycle rotary converter supplying direct current for railway use at 600 volts. All transformers are installed in the basement.

All 13,200-volt and 2400-volt switches are electrically operated from the main and local switchboards respectively.

The main generator and transmission line switches and switchboard are in the gallery above the turbine room, Figs. 12, 13 and 14, and the local commercial and railway circuits are controlled from switchboards in a bay of the turbine floor, opposite the exciter bay.

The 13,000-volt electrolytic arresters are located on a gallery above the main high-tension switch-room, Fig. 15, at which point the transmission lines enter the building.

SIGNAL SYSTEM

The turbines and exciters are controlled with reference to a system of illuminated signals. In the boiler room an illuminated signal board is suspended where it can be readily seen by the men, and designates the load being carried. If the load is to be changed, the switchboard operator signals the boiler room by blowing one blast of a signal whistle and setting a dial to illuminate the figures indicating the load in kilowatts to be carried within the next 15 min. The signal remains illuminated until the next change in the load occurs.

In the turbine room is a column of lights numbered to correspond with the turbine and exciter numbers, and a

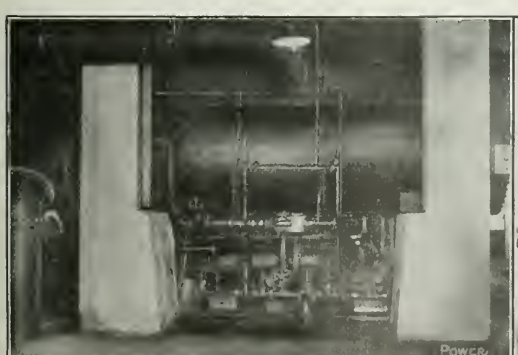


FIG. 10. CONDENSER AND AIR PUMP

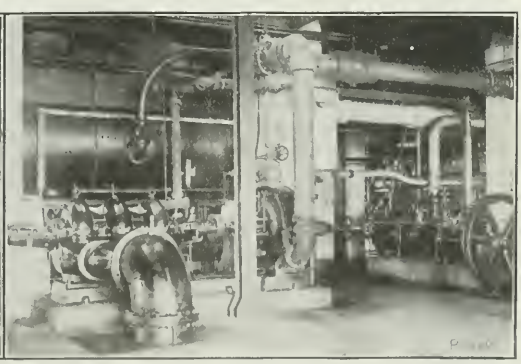


FIG. 11. CONDENSER CIRCULATING PUMP

keyboard at the head of each turbine which corresponds with one on the operating board. The signals consist of six illuminated disks, "Full Speed," "O. K.," "Shut Down," "Start," "Stand By" and "Load Off."

If the operator wishes to start a turbine, one blast of a whistle is blown and the number of the machine wanted is illuminated. At the same time the dial "Start" is illuminated on the panel of the generator to be put in service.

The engineer answers by pressing a button switch which illuminates the dial "O. K." As soon as the machine is ready for the load he also gives the signal "Full Speed," and at the same time cuts out the signal "O. K." The operator then gives one blast of the turbine-signal whistle and signal "Stand By" which is answered by the engineer with the "O. K." signal.

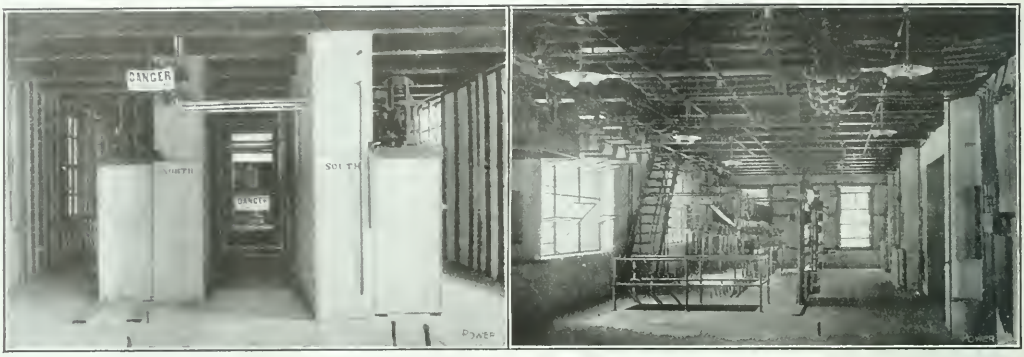
After the operator has synchronized the machine with those running he throws in the generator oil switch and switches off all signals and gives the "O. K." The engineer does the same from his panel.

When shutting down a turbine the signal whistle is blown one blast and the number of the machine to be shut down illuminated, also the order to "Stand By" given, the engineer answering "O.K." The operator then throws out the generator oil switch and signals "Load Off," when the engineer stops the turbine. As soon as the operator gets the signal "Shut Down," he cuts out the signal "Load Off," indicating "O. K." to the engineer who in turn switches off the signal "Shut Down."

In case the engineer wishes to shut down a unit because of accident, etc., he pushes an emergency buzzer in the operator's room and signals "Shut Down." The operator then gives the signals the same as for starting a machine under ordinary conditions and cuts out the defective machine as soon as another has picked up the load, signaling "Load Off" on the signal board belonging to the defective machine. When the engineer has the defective machine shut down, he switches off the signal "Shut Down" and the operator switches off the signal "Load Off," leaving the panels clear.

When the operator desires to put a turbine under load quicker than under normal conditions, he notifies the engineer by giving four blasts of the whistle in rapid succession and the signals for starting up are given as under ordinary conditions.

The same signals answer for starting and shutting



FIGS. 12 AND 13. OIL-SWITCH AND TRANSFORMER ROOMS

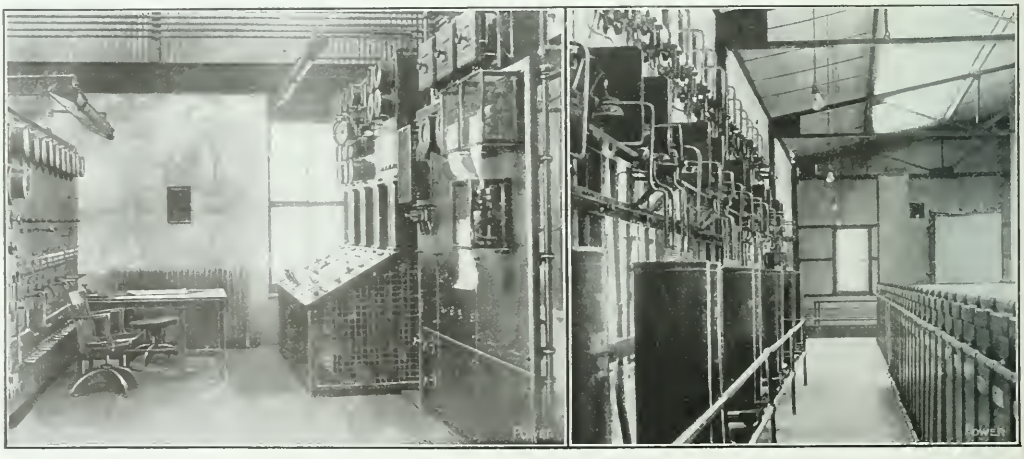


FIG. 14. OPERATING SWITCHBOARD

FIG. 15. LIGHTNING-ARRESTER ROOM

EQUIPMENT OF THE NEW PERTH AMBOY CENTRAL STATION

No.	Equipment	Make	Purpose	Kv.a.	Kw.	Volts	Amp.	Phase	Cycles	R.p.m.	Size	Pres. lb.	Hp.	Manufacturers
2	Steam turbines	Double flow	Gen. units		5000					1800		190		Westinghouse Machine Co.
3	Steam turbines	Single Stage	Exciter sets		100					2400		190		Westinghouse Machine Co.
3	Steam turbines	Single Stage	Feed pumps							2400		190	80	Kerr Turbine Co.
2	Engines	Center Crank	Fans								10′			Buffalo Forge Co.
2	Engines	Vertical	Stokers											Troy Engine & Machine Co.
1	Engine	Hoisting	Coal bucket								12x14″			Mead-Morrison Mfg. Co.
1	Compressor	Steam driven	Air								9x10x12″			Chicago Pneumatic Tool Co.
8	Boilers	Water tube	Main units									190	600	Babcock & Wilcox Co.
8	Stokers	Chain grate	Boiler furnaces											Babcock & Wilcox Co.
2	Generator	Alt. current	Main units	5000		13,200	219	3	60	800				WestinghouseElectric and Mfg.Co.
3	Generators	Direct current	Exciters		100	125	800			2403				WestinghouseElectric and Mfg.Co.
1	Converter	Rotary	Railway		500	600	833	6	60	900				WestinghouseElectric and Mfg.Co.
1	Turbine	Alberger	Circulating pump								36″			Alberger Pump and Condenser Co.
1	Turbine	Alberger	Holwell pump											Alberger Pump and Condenser Co.
1	Motor	Induction	Coal crusher			220	44	2	60	1200			20	General Electric Co.
1	Motor	Induction	Coal conveyor			220	82.8	2	60	1150			30	Westinghouse Electric & Mfg. Co.
1	Pump	Duplex	Fire								18x10x12″			International Steam Pump Co.
2	Pumps	Duplex	Oil								6x4x6″			Dean Bros. Steam Pump Works
2	Pumps	Duplex	House supply								10x6x12″			Dean Bros. Steam Pump Works
3	Pumps	Centrifugal	Feedwater								No. 3	190		Platt Iron Works Co.
2	Pumps	Rotative	Dry vacuum								12x22x18″	190		Alberger Pump & Condenser Co.
2	Pumps	Centrifugal	Hot well								4″			Alberger pump & Condenser Co.
2	Pumps	Centrifugal	Circulating								20″			Alberger Pump & Condenser Co.
2	Condensers	Surface	Turbines								10,000 sq.ft.			Alberger Pump & Condenser Co.
2	Heaters	Open	Feed water								No. 7			Platt Iron Works Co.
1	Conveyor	Belt	Coal								400 ft.			Robins Conveying Belt Co.
2	Chimneys	Kellogg	Boilers								179 ft.			M. W. Kellogg Co.
2	Recording meters	Venturi	Feed water								6 in			Builders Iron Foundry
3	Temperature and pressure gages	Recording	Steam and Water											Bristol Co.
2	Fans	Horizontal discharge	Draft											Buffalo Forge Co.
1	Regulator	Carmichael	Damper											John Bushnell & Co.
2	Tachometers	Direct coupled	Speed indicator											Schaefer & Budenberg Mfg. Co.
2	Filters	White Star	Oil											Pittsburgh Gage & Supply Co.
	Electrical apparatus													Westinghouse Electric & Mfg. Co.
24	Valves	Simplex	Blowoff											Pratt & Cady Co.

down the exciter units, except that the exciter numbers are used instead of the turbine numbers.

Pipe Color Scheme

Another interesting feature is the pipe-color scheme, all pipes used for the same kind of service being painted the same color. All high-pressure steam pipes are white; exhaust-steam pipes, buff; fresh-water, low-pressure, blue; fresh-water, high-pressure boiler feed, blue with white band; salt water, green; oil delivery and discharge, brass or bronze yellow; air lines, gray; fire lines, red; electric lines, black and red border or fittings

⁂

The Water-Glass Method of Testing Leakage

In an appendix to its report submitted at the last meeting, the Committee on Tests of the American Society of Mechanical Engineers suggests the following test for leakage. It is so simple that anyone may make it, and it sometimes leads to surprising results.

The water necessary to restore the water level to its height when the test was started, or which is pumped in during the test to maintain the level constant, is the amount of water evaporated, if for a given height of water in the glass there is the same amount of water in the boiler before and after the test. This may not be the case if the rate of evaporation is different, and, for the same amount of water contained, the water level is raised or lowered by the presence in the water of more or less steam bubbles. Again it may not be the case if there is a change in the relative density of the contents of the boiler and the water column. If the water column is allowed to stand without blowing until the water becomes cold, its contents will be denser and it will take a shorter column to balance the hot water in the boiler than if it were at a higher temperature. For the same height of water in the boiler the water in the gage glass will stand higher than after the contents of the column become cool. This is the reason for the recommendation that the water column should not be blown down during a water-gage test nor for a period of at least one hour before it begins.

Of the water evaporated some may be:

Lost through leakage.
Condensed in the steam pipe.
Drawn off for use.

If it is desired to determine one of these quantities, the others must be eliminated or known. If it is wished to know how much is lost by leakage, for example, it is best to eliminate the third item by not drawing any of the steam out of the system under test. The difference between the amount evaporated, as determined by the difference in the water level and the amount condensed in the pipe, is the leakage. The condensation must be drawn off and weighed. Of course it must be allowed to cool to below 212 deg. before it is exposed to the atmosphere. The appendix referred to is as follows:

To determine the leakage of steam and water from a boiler and steam pipes, etc., the water-glass method may be satisfactorily employed. This consists of shutting off all the feed valves (which must be known to be tight) and the main feed valve thereby stopping absolutely the entrance or exit of water at the feed pipes to the boiler; then maintaining the steam pressure (by means of a very slow fire) at a fixed point, which is approximately that of the working pressure, and observing the rate at which the water falls in the gage glasses. It is well, in this test, as in other work of this character, to make observations every ten minutes, and to continue them for such length of time that the differences between successive readings attain a constant rate. In many cases the conditions will have become constant at the expiration of fifteen minutes from the time of shutting the valves and thereafter the fall of water due to leakage of steam and water become approximately constant. It is usually sufficient, after this time, to continue the test for two hours, thereby obtaining a number of half-hourly periods. When this test is finished, the quantity of leakage is ascertained by calculating the volume of water which has disappeared, using the area of the water level and the depth shown on the glass, making due allowance for the weight of 1 cu.ft. of water at the observed pressure. The water columns should not be blown down during the time a water-glass test is going on, nor for a period of at least one hour before it begins.

If there is opportunity for condensation to occur and collect in the steam pipe during the leakage test, the quantity should be determined as closely as desirable, and properly allowed for.

⁂

The industrial prominence of Pittsburgh is seen by its fuel consumption. More fuel is consumed in Pittsburgh and its immediate vicinity, and more coal is shipped to and through the Pittsburgh district, than in any other district in the world, according to Edward W. Parker, of the United States Geological Survey. With a population of about one-ninth of that of Greater New York the consumption of coal alone in Pittsburgh is nearly equal to that of the much larger city. Greater New York consumed in 1911 approximately 19,000,000 short tons and Pittsburgh used about 16,500,000 short tons. But Pittsburgh consumes several million tons of coke and considerable quantities of natural gas, which added to the coal consumption, gives that city a good lead over New York as a burner of fuel.—"Wood Craft."

Heat Balance in Steam Boilers

By Lionel S. Marks

SYNOPSIS—Obtaining the heat balance of a furnace and boiler is a process of accounting for all the heat that would have been generated by the fuel if combustion had been perfect. This article develops a comparatively simple method of calculating it from the results of a complete test.

With a perfect furnace and boiler all the heat of perfect combustion of the fuel would be utilized in raising the temperature of the feed water and in evaporating it. In the best actual plants, the efficiency is from 75 to 80 per cent.; that is, from 75 to 80 per cent. of the heat of perfect combustion actually goes to the feed water. With the average plant, about 60 per cent. of the heat is utilized, while in poor plants the efficiency is still lower. When the efficiency of the plant is very low it is generally possible to ascertain the cause of its poor performance by inspection. With plants of higher efficiency it is not so easy and it becomes necessary to have recourse to flue-gas analyses and other observations. If it is desired to find out exactly what has become of the heat which should have been generated by the fuel and have gone into the feed water; that is, if it is desired to obtain the "heat balance" of the furnace and boiler, a complete test is necessary. The object of this article is to present a comparatively simple method of calculating the heat balance of a boiler from the results of such a test.

A boiler test which aims at a reasonable degree of completeness will generally include the following among the observations:

The weight of water evaporated; the temperature of the feed water, and the pressure and quality (or superheat) of the steam.

The temperature, pressure and humidity of the air, and the temperature and composition of the flue gases. The weight of coal burned; its proximate analysis and heat of combustion.

The weight and composition (or heat of combustion) of the refuse in the ashpit.

From these observations, it is possible to determine in detail what has become of the heat of combustion of the fuel. It has generally been considered necessary to add to the above observations the ultimate analysis of the coal, an analysis which must be carried out by a chemist and which is tedious and expensive. As will be shown later, it is generally possible to obtain the heat balance with an accuracy which is within the attainable degree of accuracy of a boiler test itself, without having recourse to the ultimate analysis.

The complete heat balance of a furnace and boiler takes into account five principal dispositions of the heat of perfect combustion of the fuel. They are as follows:

1. The heat utilized in raising the temperature of the feed water and in evaporating it.

2. The heat not developed as a result of incomplete combustion. This heat divides itself into three parts:

(a) The heat of combustion of the carbon and other combustible matter which has fallen into the ashpit and which is carried away with the ashes.

(b) The heat of combustion of any CO which may be going up the chimney.

(c) The heat of combustion of any hydrocarbons which may be escaping unburned with the chimney gases.

3. The heat being lost up the chimney as sensible heat of the dry chimney gases.

4. The heat being lost up the chimney in water vapor which accompanies the dry chimney gases. This water vapor comes from three separate sources:

(a) That which results from the combustion of hydrogen in the coal.

(b) That which comes to the furnace as moisture in the coal.

(c) That which arrives in the furnace as humidity in the air.

5. The heat lost by radiation and conduction, or heat which is otherwise unaccounted for.

The problem of determining the heat balance of a boiler resolves itself into the problem of finding the values of the quantities 1, 2, 3 and 4. The radiation and conduction must be determined by heat balance; it is the quantity remaining unaccounted for after all the other quantities have been determined.

The methods of determining these separate quantities are given below:

1. *Heat given to the feed water.* This quantity is readily determined from a knowledge of the weight of water evaporated per pound of coal, the temperature of the feed water, and the pressure and quality (or superheat) of the steam. When expressed as a percentage of the total heat of perfect combustion of the fuel burned, it measures the efficiency of the boiler plant. Its value in ordinary practice varies from 60 to about 75 per cent.

2. *Heat lost by incomplete combustion.* The object of a furnace is to burn the coal as completely as possible with the smallest possible air supply. A perfect furnace would lose no combustible matter through the grate bars into the ashpit; would convert all the carbon into carbon dioxide; would give off no unburned hydrocarbons; and would have no air of dilution; that is, would send no unused oxygen up the chimney. This perfect furnace has not yet been realized, nor is it likely to be closely approximated to with solid fuels. With liquid fuels, however, the losses from incomplete combustion and from the admission of excess air can be reduced to a very small quantity.

(a) *The heat lost with combustible falling into the ashpit.*

To determine how much heat of combustion is lost with the refuse in the ashpit, it is necessary to know the weight of the refuse and its composition, or its heat of combustion. There are, in general, three ways of determining these quantities:

(1) An inspection of the heap of refuse at the conclusion of the test may indicate to a trained observer the approximate composition of the refuse. This method is not satisfactory by itself. The refuse is generally wet when its weight is determined and the estimate of combustible must be preceded by an estimate of the amount

of moisture. In those cases where all the combustible matter which has fallen into the ashpit is well coked, it may not be very difficult to estimate the percentage by weight of combustible in the dry refuse, and since the combustible in that case will be carbon it is possible to obtain the heat that would be developed by the combustion of the refuse.

A number of modern furnaces separate the green coal which sifts through the grates from the coked fuel which falls through with the ash, and in such furnaces an estimate of the combustible in the refuse may be possible. In those cases where the siftings of green coal and of coked fuels fall into the same place and are mingled together, such an estimate becomes too uncertain.

(2) The amount of combustible in the refuse can also be obtained from the total weight of coal that has been burned and the percentage of ash which the proximate analysis of the coal shows it to contain. From these quantities, it is easy to calculate the total true ash, and if this is subtracted from the dry refuse in the ashpit, we get the total combustible matter, but we do not get any light at all on the composition of this combustible matter. depends entirely upon the accuracy with which the sample burned represents the average heat of combustion of the refuse pile.

The heat of combustion of the fuel in the refuse is seldom more than 3 to 5 per cent. of the heat of combustion of the fuel fired in well operated plants. In view of the fact that it is not possible in a boiler test to obtain an accuracy greater than 1 per cent., and generally not greater than 2 per cent., it is not important that the heat of combustion of the fuel in the refuse should be determined with very great accuracy. If an error of 10 per cent. is made in the estimate, either of the amount of combustible in the refuse or in its heat of combustion, it will make an error which generally would not be more than $\frac{3}{10}$ of 1 per cent. in the heat balance of the boiler. In determining the heat balance of a boiler, the maximum error is likely to occur in this item.

2 (b). The heat lost by the combustion of some of the carbon to CO instead of to CO_2, is readily determinable from the flue-gas analysis. Each pound of carbon burned to CO_2 gives up 14,500 B.t.u. Each pound of carbon burned to CO gives up only 4450 B.t.u. Consequent-

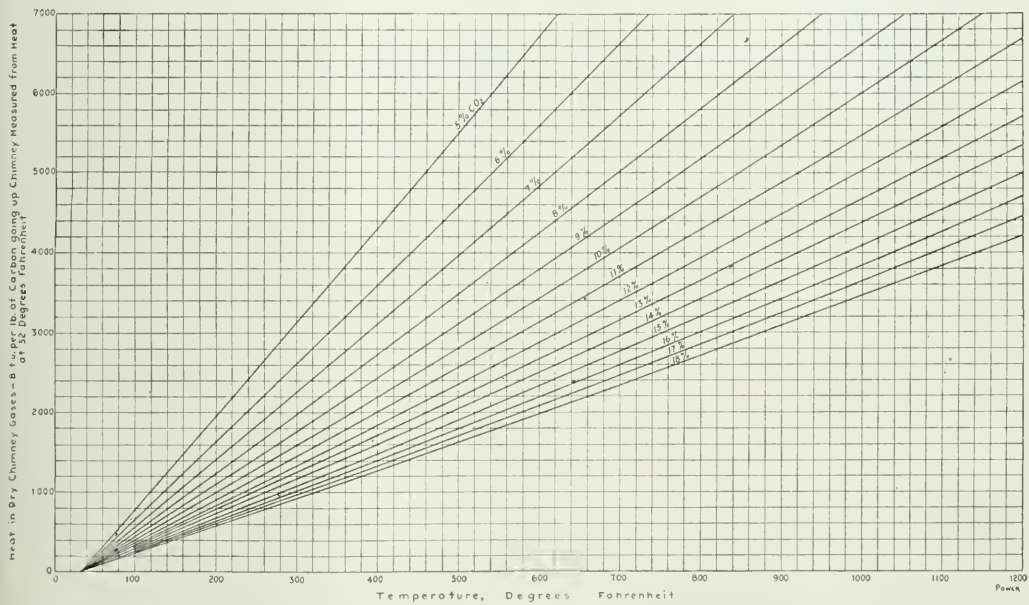


FIG. 1. CHART FOR DETERMINING THE AMOUNT OF HEAT ESCAPING WITH THE CHIMNEY GASES

The use of the second method to check the first method, has been found by the writer to work satisfactorily in those cases in which the refuse contains only coked fuel. In other cases, resort must be had to the next method.

(3) The heat of combustion of the refuse may be determined by the actual combustion of a fair sample of the refuse. This method does not give entirely satisfactory results in consequence of the great difficulty of getting a fair sample. The refuse generally contains large clinkers and it is often impracticable to break up all the clinkers in order to get a fairly homogeneous pile from which to begin to select a sample. The accuracy of this method

ly, for each pound of carbon burned to CO there is a loss of 10,050 B.t.u. If there is any CO present its amount will be determined by the flue-gas analysis. The weight of carbon in a cubic foot of CO_2 is the same as the weight of carbon in a cubic foot of CO at the same pressure and temperature. Consequently, the weight of carbon burned to CO has the same ratio to the weight burned to CO_2 as the volumes of the two gases. If x = the percentage of the total carbon burned to CO_2, and y the percentage burned to CO, then $x + y$ is the total carbon burned and

$$\frac{y}{x + y}$$

is the fraction burned to carbon monoxide. Consequently,

$$10{,}050 \times \frac{y}{x+y}$$

is the heat of combustion lost through the burning of carbon to carbon monoxide per pound of carbon going up the chimney. This can be expressed in B.t.u. per pound of coal fired when the analysis of the coal, and the percentage of the total carbon falling through into the ashpit are known.

With good operation of the furnace there should not be more than a trace of CO except in those cases where the furnace is being forced very much beyond its proper capacity. If the CO present exceeds 1 or 2 per cent., it may safely be inferred that the incomplete combustion which this indicates extends also to the hydrocarbons.

2 (c) Heat lost with hydrocarbons escaping unburned up the chimney.

Whenever visible smoke escapes from a chimney it is probable that some hydrocarbons are escaping unburned. The denser the smoke, other things being equal, the greater is the probability of the loss of unburned hydrocarbons. The ordinary flue-gas analysis does not give any

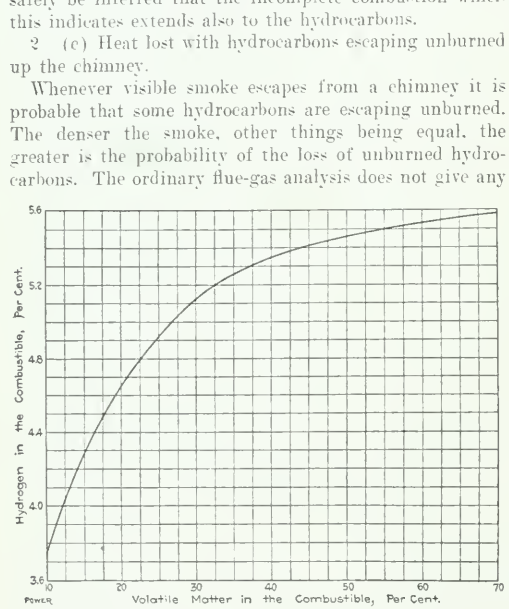


FIG. 2. CHART FOR DETERMINING HYDROGEN FROM THE PERCENTAGE OF VOLATILE MATTER

definite indication of the presence of these gases. Under normal conditions of operation of steam plants, with not more than a trace of CO and with little or no visible smoke, one may feel pretty sure that there is no appreciable loss of hydrocarbons up the chimney. In other cases, there may be such a loss, but there is no available means of determining its amount. Special tests and also the heat balances of many boilers indicate that this loss is normally quite negligible.

3. *Heat lost with the dry chimney gases.* The gases escaping up the chimney are carbon-dioxide, oxygen, carbon-monoxide and nitrogen. These are usually collected over water and measured over water. They are, consequently, saturated with water vapor and their analysis shows nothing at all about the content of water vapor of the gases as they are going up the chimney. The heat carried away by these gases is the heat that would be given up by cooling the dry gases from the chimney temperature to the temperature of the air in the boiler room. The amount of this heat for each of the constituents is equal to

$$wC_p\,(T_c - T_a)$$

where

w = Weight of each of these constituents per pound of carbon going up the chimney;

C_p = Mean specific heat at constant pressure from the boiler-room temperature up to the temperature of the chimney;

T_c = Temperature of the chimney;

T_a = Temperature of the entering air.

The specific heat of the gases going up the chimney varies with the temperature, and, according to the best authorities, the mean specific heat from 32 deg. to any temperature t deg., is as follows:

For

Oxygen	$C_P = 0.2125 + 0.00001\ (t - 32)$
Nitrogen	$= 0.243 + 0.000012\ (t - 32)$
Carbon monoxide	$= 0.243 + 0.000012\ (t - 32)$
Carbon dioxide	$= 0.201 + 0.00041\ (t - 32)$ $- 0.000000055\ (t - 32)^2$

To facilitate the calculation of the total heat escaping up the chimney, the chart, Fig. 1, has been prepared. In this chart the horizontal scale gives the temperature of the gas; the vertical scale gives the sensible heat being carried away by the gases in B.t.u. per pound of carbon going up the chimney. The lines are labeled according to the percentage of CO_2 which analysis shows to be present. These curves are calculated on the assumption that the gas contains (in addition to the percentage of carbon dioxide marked on the curves) 80 per cent. of nitrogen, and that the rest of the gas is oxygen. In those cases where some CO is present, the correction is quite negligible if the CO is reckoned as CO_2. For example, with 15 per cent. of CO_2 and 2 per cent. of CO, and with a chimney temperature of 632 deg. F., the heat of the gases is 2183 B.t.u. If it is assumed, for the purposes of this calculation, that the CO acts as CO_2, we have 17 per cent. of CO_2, the sensible heat of which is 2200 B.t.u.; the difference is only 17 B.t.u. In using Fig. 1 the heat contained in the gases at boiler-room temperature must be subtracted from the heat at chimney temperature in order to find the heat carried away by the dry gases.

The amount of heat escaping with the dry gases up the chimney can readily be expressed, as a percentage of the total heat of perfect combustion when the relation of the carbon escaping up the chimney to the weight of fuel has been determined from the proximate analysis of the fuel, and the correction has been made for the carbon falling through into the ashpit.

4. The heat escaping up the chimney with the water vapor is equal to the total heat of this vapor minus the heat which it has when at the temperature of the room. It is necessary, however, to decide whether the vapor must be considered in the vapor or the liquid form at this lower temperature. This question is decided separately under each of the following headings:

(a) The moisture resulting from the combustion of hydrogen in the coal.

To determine the amount of this water vapor, it is necessary to know how much hydrogen is present in the dry coal. The usual way of determining this quantity has been to make the so called ultimate analysis of the coal, which determines not only the hydrogen but also the total carbon, oxygen, nitrogen and sulphur. As already pointed

out, this determination is tedious and expensive. It is possible to determine the hydrogen from the proximate analysis with a degree of accuracy which is sufficient for all ordinary purposes. As was pointed out by the writer in an article in POWER, Vol. 29, page 928, December, 1908, there is a definite relation between the hydrogen content of the combustible matter of American coals, and the total amount of the volatile matter expressed as a percentage of the total combustible of the coal. This relationship is shown on the accompanying curve, Fig. 2.

Professor Diederichs has deduced an equation for this curve of the form

$$H = v\left(\frac{7.35}{v + 10} - 0.013\right)$$

where

H = Percentage weight of hydrogen in the combustible;

v = Percentage weight of volatile matter in the combustible.

By the use of either the curve or the equation, it is possible to determine the hydrogen content of a coal with an accuracy of about $\frac{2}{10}$ of 1 per cent.

The carbon in the volatile matter of the coal is determinable with less accuracy by the curve shown in Fig. 3. The error in this case may be as much as 2 per cent. for the more common fuels; while for lignites and other special fuels, it may be even greater. The total carbon in coal is the sum of the fixed carbon and of the carbon in the volatile matter. If this latter is determined by the use of Fig. 3, the total carbon per pound of coal can be readily determined.

Assuming that it is sufficiently accurate to take the hydrogen and carbon content of the volatile combustible matter of a coal from the two curves given, it becomes possible to get the practical equivalent of that part of the ultimate analysis of the coal which is required for the calculation of a heat balance.

When hydrogen burns to H_2O, its weight increases ninefold; consequently, the weight of water vapor resulting from the combustion of hydrogen is immediately determinable. The heat carried up the chimney by this moisture is given by the equation

$$Q = w(H - h)$$

where

w = Weight of the H_2O formed per pound of coal burned;

H = Total heat per pound of steam at chimney temperature;

h = Heat of one pound of water at boiler-room temperature.

The total heat H of water vapor at ordinary chimney temperatures and at the pressures commonly occuring in the chimney, is practically independent of the pressure, and is given in Fig. 4. The heat of one pound of water h at the temperature of the boiler-room may be taken as the boiler-room temperature minus 32.

(b) Moisture in the coal.

The proximate analysis of the coal gives the total weight of moisture content in the coal. The heat which it carries up the chimney is calculated as in the previous paragraph.

(c) Moisture entering with the air.

Air under ordinary atmospheric conditions, contains some water vapor. The weight of this vapor cannot exceed the weight of an equal volume of dry and saturated steam at the same temperature. The accompanying curves, Fig. 5, show approximately the ratio of the heat carried up the chimney by the dry chimney gases to the heat being carried away by the water vapor which entered with the air. As this latter quantity is always a small fraction of the heat of the dry chimney gases, it is not necessary to calculate its amount exactly. The curves have been calculated on the assumptions that the specific heat of water vapor is twice that of the chimney gases, and that the chimney gases have the physical properties of air. By reference to the curves, it will be seen that with air at 80 deg. F. and humidity 80 per cent., the heat being carried up the chimney with the moisture which entered with the air, is $\frac{1}{34}$ or 3 per cent. of the heat of the dry chimney gases. The chimney gases seldom carry off more than 15 per cent. of the heat of perfect combustion

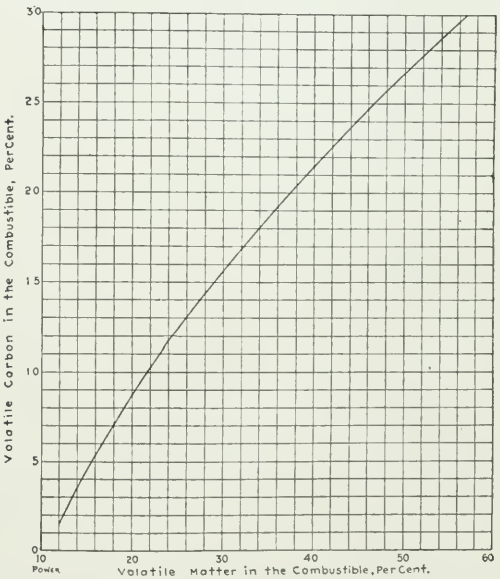


FIG. 3. CHART FOR DETERMINING THE CARBON IN THE VOLATILE MATTER

of the coal. Assuming this amount, the total heat in the water vapor under the suggested conditions is

$$\frac{1}{34} \times 15 = 0.5 \text{ } \textit{per cent.}$$

approximately of the heat of perfect combustion of the coal. This quantity is seldom exceeded. The loss is commonly not more than 0.2 to 0.3 per cent.

5. Any heat not accounted for under the preceding headings is assumed to be lost by radiation and conduction. This unaccounted for quantity is seldom less than 2 per cent. of the heat of perfect combustion and may be as much as 4 or 5 per cent. Any test in which this quantity falls outside the limits of 2 and 5 per cent. should be looked upon with suspicion until some explanation has been found. The writer has come across a number of tests showing high efficiencies in which this unaccounted for quantity has a negative value. Such tests must be rejected as worthless.

As an example of the determination of the heat balance of a boiler plant, we may assume the following data from a boiler test:

Weight of feed water evaporated per pound of coal fired	9 lb.
Temperature of the feed water	50 deg. F.
Pressure of the steam, absolute	160 lb. per sq.in.
Superheat of the steam	60 deg. F
Temperature of the air entering the boiler room	70 deg. F.
Humidity of the air entering the boiler room	60 per cent.
Temperature of the flue gases	550 deg. F.
CO_2 in the flue gases by volume	13 per cent.
CO in the flue gases by volume	1 per cent.
Heat of combustion of the coal as fired	14,000 B.t.u.
Proximate analysis of the coal	
Moisture	4 per cent.
Volatile matter	25 per cent
Fixed carbon	62 per cent.
Ash	8 per cent.
Sulphur	1 per cent.
Weight of refuse in the ashpit per pound of coal fired	0.131 lb.
Estimated moisture in the refuse by weight	20 per cent.
Estimated carbon in the dry refuse by weight	30 per cent.

The proximate analysis of the coal shows it to contain 12 per cent. of noncombustible matter (moisture and ash), and 88 per cent. of combustible. The percentage composition of the combustible matter is, consequently:

Volatile matter $25 \times \frac{100}{88} = 28.3$ per cent.

Fixed carbon $62 \times \frac{100}{88} = 70.5$ per cent.

Sulphur $1 \times \frac{100}{88} = 1.1$ per cent.

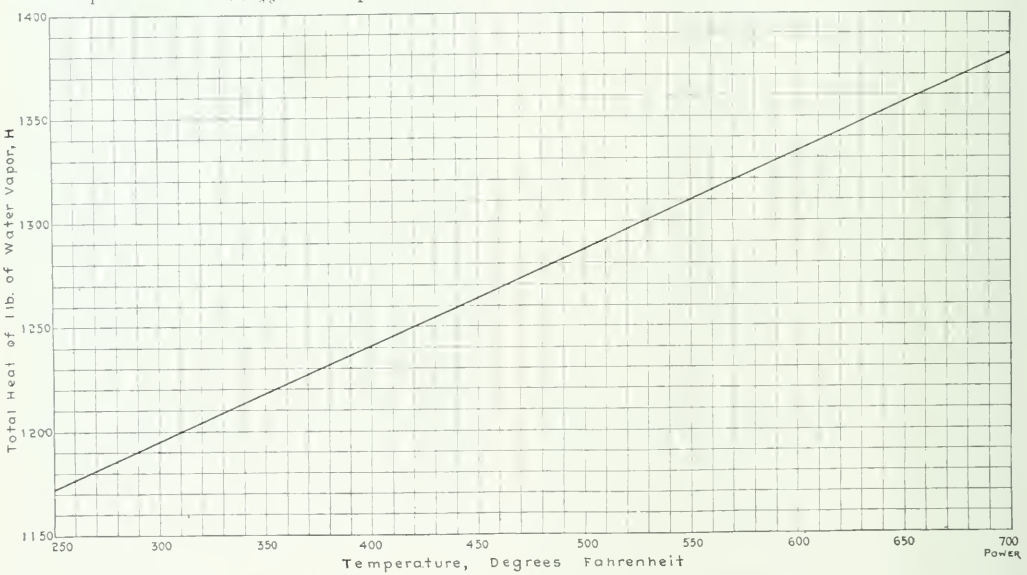


FIG. 4. CHART SHOWING TOTAL HEAT PER POUND OF WATER AT CHIMNEY TEMPERATURES

With a coal whose combustible matter has the above composition we see from Figs. 2 and 3 that the volatile hydrogen is 5.1 per cent., and the volatile carbon is 14.5 per cent. of the combustible matter.

The total carbon is 14.5 + 70.5 = 85 per cent. of the combustible, or

$$85 \times \frac{88}{100} = 74.8 \textit{ per cent.}$$

of the coal is fired.

From the above data we determine the heat balance as follows:

1. The heat given to one pound of water is found from the steam tables to be

$$1230 - 58 = 1172 \text{ B.t.u.}$$

Consequently the heat absorbed by the feed water per pound of coal fired is

$$9 \times 1172 = 10{,}548 \text{ B.t.u.}$$

The efficiency of the boiler is

$$\frac{10{,}548}{14{,}000} = 75.3 \textit{ per cent.}$$

2a. The refuse in the ashpit is 0.131 lb. per lb. of coal fired. An estimate of 20 per cent. of moisture gives 0.105 lb. of dry refuse, and the further estimate of 30 per cent. of carbon in the dry refuse gives 0.031 lb. of carbon, and 0.074 lb. of ash per lb. of coal fired.

The proximate analysis of the coal shows that the ash should be 0.08 lb. This is a fairly good check. Assuming that the amount of ash given by the proximate analysis is correct, we find $0.105 - 0.08 = 0.025$ lb. of carbon falling unburned through the grate bars per pound of coal fired. The heat lost by this incomplete combustion is $0.025 \times 14{,}500 = 362$ B.t.u., or

$$\frac{362}{14{,}000} = 2.6 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

2b. The flue gases contain 13 per cent. of CO_2 and 1 per cent. of CO. The carbon going up the chimney as CO is, consequently, $\frac{1}{14}$ of the total carbon going up the chimney.

The total carbon contained in one pound of coal is 0.748 lb. and of this 0.025 lb. falls into the ashpit. The carbon going up the chimney is, consequently, $0.748 - 0.025 = 0.723$ lb. per lb. of coal fired.

The carbon burned to CO is then $\frac{1}{14} \times 0.723 = 0.0516$ lb., and the heat lost thereby is $0.0516 \times 10{,}050 = 519$ B.t.u., or,

$$\frac{519}{14{,}000} = 3.7 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

3. The heat lost with the dry chimney gases is ob-

tained from Fig. 1. With 14 per cent. of CO_2 and CO at 550 deg. F. the sensible heat of the dry gases is 2280 B.t.u. per lb. of carbon going up the chimney. This is measured above 32 deg. F. The heat of the gases at 70 deg. F. (the boiler room temperature) is seen from the same figure to be 160 B.t.u. Consequently the loss up the chimney is 2280 — 160 = 2120 B.t.u. This corresponds to 2120 × 0.723 = 1533 B.t.u., per pound of coal fired, or

$$\frac{1533}{14{,}000} = 11.0 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

4a. The moisture resulting from the combustion of the hydrogen in the coal is 9 × 0.051 lb. per lb. of combustible, or 9 × 0.051 × $^{77}/_{100}$ = 0.404 lb. per lb. of coal fired. The heat which it carries with it is seen by reference to Fig. 4, to be 0.404 (1310 — 58) = 505.8 B.t.u., or

$$\frac{505.8}{14{,}000} = 3.6 \textit{ per cent.}$$

of the heat of perfect combustion of the coal.

4b. The moisture in the coal is 0.04 lb. per lb. of coal. The heat which it takes up the chimney is 0.04 (1310 — 58) = 50.1 B.t.u., or, 0.4 per cent., approximately, of the heat of perfect combustion of the coal.

4c. With air at 70 deg. F., and humidity 60 per cent., the vapor entering with the air is seen from Fig. 5 to carry up the chimney $^{1}/_{62}$ of the heat of the dry chimney gases. This heat has been seen to be 11 per cent. of the heat of perfect combustion of the coal. The loss due to the moisture in the air is consequently

$$\frac{11.0}{62} = 0.2 \textit{ per cent.}$$

approximately.

5. The heat lost by radiation and conduction, or otherwise unaccounted for, is obtained by balance. The disposition of the heat is seen to be as follows:

Heat given to the feed water	75.3 per cent
Loss by unburned carbon in ashpit	2.6 per cent
Loss by CO up the chimney	3.7 per cent
Loss with dry chimney gases	11.0 per cent
Loss with moisture from hydrogen in the coal	3.6 per cent
Loss with moisture in the coal	0.4 per cent
Loss with moisture in the air	0.2 per cent
Radiation, conduction, etc.	3.2 per cent.
	100.0 per cent.

As was pointed out earlier, the use of the curve in Fig. 3 for determining the carbon in the volatile matter of a coal, may give results which are in error by 2 per cent. or more. To ascertain the influence of such an error on the heat balance the preceding calculations have been repeated, taking the volatile carbon as 16.5 per cent. instead of 14.5 per cent. shown by the curve. The only changes which this produces is to increase item 2 (b) by 0.1 per cent., item 3 by 0.3 per cent., and consequently to reduce item 5 by 0.4 per cent. These changes are unimportant and justify the use of Fig. 3.

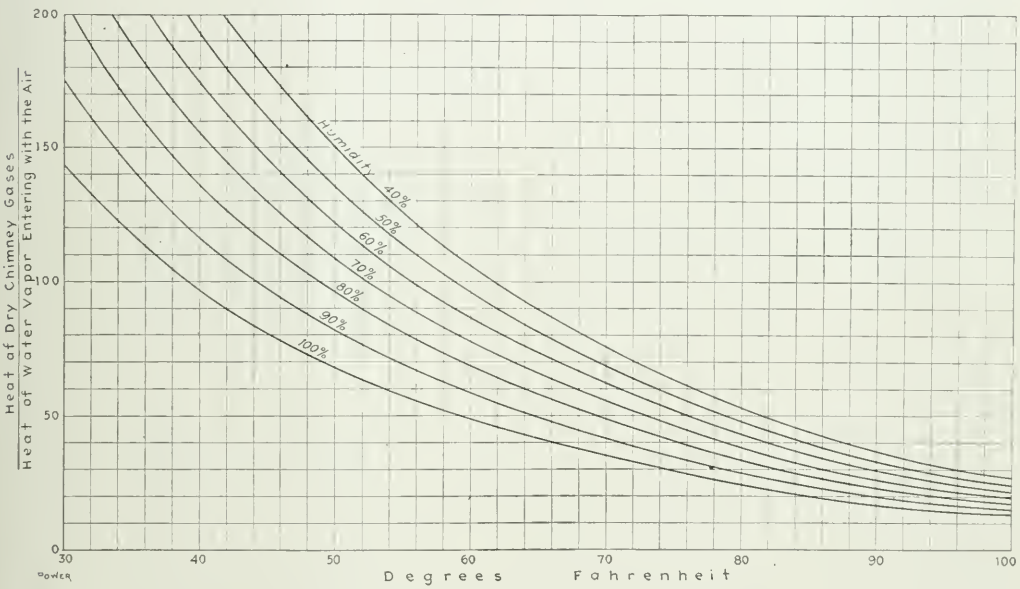


FIG. 5. CHART SHOWING AMOUNT OF HEAT CARRIED UP THE CHIMNEY BY THE WATER VAPOR OF THE AIR

Double Acting Hacksaw Blade

A new design of hacksaw blade is being placed on the market by Alexander Reitlinger, 201 William St., New York City. It differs from other saw blades in that each set of four teeth pitch in opposite directions with a straight tooth between each set of slanting teeth. Claims made by the manufacturer for these saws are that they will cut faster and cleaner than when made with the teeth all in one direction, and that they will cut iron pipe without breaking the teeth. When used in a power-driven frame the blade must be used in one which does not lift on the back stroke, in order that it may cut on both strokes.

ELECTRICAL DEPARTMENT

The Storage Battery—I

By John A. Randolph

There are several methods by which electrical energy can be generated for practical use, the principal ones of which are: the electrostatic, the electrodynamic and the electrochemical. The first finds its chief use in the laboratory while the latter two are universally employed for commercial purposes. The electrochemical method is confined to the battery, the energy being produced by the action of a chemical compound upon two plates or electrodes, one or both of which is made of metal.

There are two kinds of battery, the primary type and the storage or accumulator class. Under the first classification belong all batteries designed either to be replenished after discharge by the addition of fresh plates, mixtures or solutions or to be completely replaced by a new outfit. This type is used on circuits employing small intermittent currents. The batteries of the storage class are so composed that upon discharge they can be readily replenished electrolytically. In other words, they are recharged as the resultant effect of a current passed through them in a direction opposite to that of discharge. The storage battery is always used where it can be quickly and conveniently connected for recharging to another source. The primary type is used on circuits which would not justify the more expensive installation of a battery of the other class.

The storage battery is composed of three fundamental working elements, namely: the positive plate, the negative plate and the electrolyte. There are several processes used in the manufacture of the plates, but the one most generally employed consists in making the positive elements of lead peroxide (PbO_2) and the negative of sponge lead (Pb). The electrolyte consists of sulphuric acid (H_2SO_4) diluted with water (H_2O). The active materials are held in their respective positions by lead grids.

There are various theories in regard to the chemical reactions which take place in a storage cell, but the one most generally accepted is that the passage of the current upon discharge causes the acid to react upon the active materials of the plates forming in their places lead sulphate ($PbSO_4$) the reaction being accompanied by a reduction of part of the acid and the formation of water in its place. This is the cause of the decrease in the density of the electrolyte observed upon discharge. The chemical formula expressing the reaction at the positive plate upon discharge is

Lead Peroxide		Sulphuric Acid		Lead Sulphate		Water		Oxygen
PbO_2	+	H_2SO_4	=	$PbSO_4$	+	H_2O	+	O

That of the negative plate is

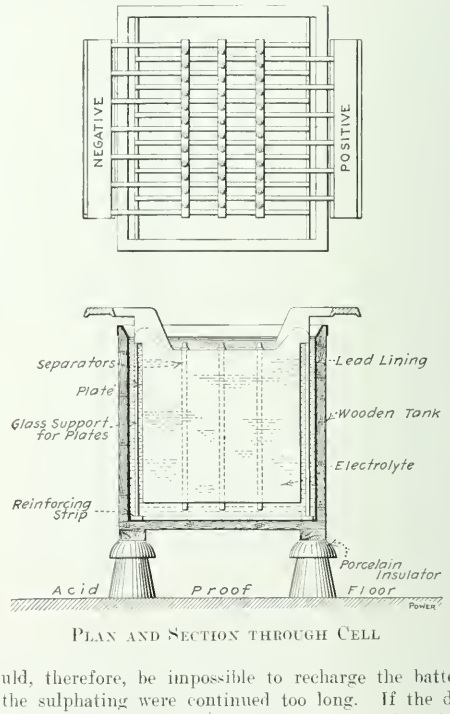
Sponge Lead		Sulphuric Acid		Lead Sulphate		Hydrogen
Pb	+	H_2SO_4	=	$PbSO_4$	+	H_2

Combining these two equations, we have

$$PbO_2 + Pb + 2\,H_2SO_4 = 2\,PbSO_4 + 2\,H_2O$$

The latter equation is known as the fundamental equation of the storage battery.

It is evident, from the foregoing analysis, that if the discharge were continued indefinitely, the active materials of the plates would practically all be changed to lead sulphate. This would ruin the battery because of the chemical nature of the sulphate. This compound offers a very high resistance to the electric current and, when not mixed with another substance of a conducting nature, it is extremely difficult to decompose it electrolytically. It would, therefore, be impossible to recharge the battery if the sulphating were continued too long. If the discharge is stopped while other materials remain mixed with the sulphate in sufficient quantities to insure a ready passage of the charging current, the sulphate can be easily broken up and the battery recharged without difficulty.



Plan and Section through Cell

Upon charging, the current is passed through the battery in the direction opposite to that of discharge, with the result that the reactions expressed in the foregoing equations are reversed. The lead sulphate is reduced, the active materials—lead peroxide and sponge lead—are restored to their respective plates and the acid taken from the electrolyte on discharge returns to it, the water

previously formed disappearing. This replenishment of the electrolyte causes the rise in density observed upon charging. If the equations of discharge are read from right to left, they will express in each case the reaction upon charging. The combined or fundamental equation will now read

$$2PbSO_4 + 2H_2O = PbO_2 + Pb + 2H_2SO_4$$

Capacity

The capacity of a battery is rated according to the current it can deliver for a given duration of time. It is expressed in ampere-hours and is, therefore, the product of the rate of current flow, or amperage, and the time in hours during which this flow is maintained. For instance, an 8000-ampere-hour battery is one which can deliver a current of 1000 amperes for eight hours or a current of 2000 amperes for four hours. The rate of current flow depends upon the combined area of the positive plates exposed to the electrolyte, the area of each plate being considered as the sum of the areas of its two sides. The capacity, on the other hand, is dependent not only upon the size and construction of the plates, but upon the quantity, quality and density of the electrolyte and the nature of the active materials employed. To secure the most economical results, the active material should be so disposed as to allow the ready circulation of the acid through all its parts. For this reason, it should be porous and offer a short path for the electrolyte from one side of the plate to the other. The holding grids should be so constructed that they will make good electrical contact at all times with the active material. With the formation of sulphate at discharge, the active material expands, while upon charging, it contracts to its former size. The grid should be able to adapt itself to these changes. If it does not, the active material, as it alternately increases and decreases in volume, will be loosened from the grid, causing poor electrical contact and a gradual breaking apart of the paste, which will cause the latter to fall to the bottom of the cell and become useless. Moreover, unless the grid is designed for proper adjustment to the changes in the paste, there will be a tendency for the grid to warp or buckle which will further enhance the efficiency and life of the battery.

Voltage

When the battery is first placed on charge, the voltage will rise rapidly for a short time and then assume a slower and more gradual increase for the remainder of the period except near the end, when it will again rise rapidly to a maximum. This action will be reversed in a similar manner upon discharge. These conditions, however, are dependent upon the disposition of the active materials, the temperature and the density of the electrolyte. Unless the paste is so arranged that the acid can percolate through it freely, the reactions will be retarded, causing a corresponding variation of voltage upon discharge and hindering the normal rise upon charge. Moreover, the activity of the electrolyte depends upon its density and is also affected to a certain extent by the temperature.

Construction and Installation

As usually constructed, the plates are so spaced that those of one polarity fit alternately into the spaces between those of the opposite sign, sufficient clearance being maintained to prevent short-circuit and to allow ample space for the electrolyte. All the plates of like polarity are joined together outside the cell, the positive connection being at one side and the negative at the other. The plates are held apart by separators of hard rubber, wood or glass. The electrodes and electrolyte are contained in a jar or tank made generally of glass, hard rubber, or wood lined with lead. Glass is used on small stationary batteries, while the lead-lined wooden tank is employed on the larger sizes. Hard rubber finds its principal application on batteries used for traction work and portable purposes. When the containers are of glass, the plates are supported directly from the sides of the jar, but in the lead-lined tank, they rest upon two independent glass supports, one on either side of the tank. The jars or tanks are thoroughly insulated from the earth and from one another by supports which usually consist, in the larger sizes, of a combination of triple petticoat porcelain insulators and wooden frames or blocks. The construction of a typical large-sized battery cell is shown in the illustration.

The floor of the battery room should be of wood, brick, vitrified tile or asphalt but never of cement or a material affected by acid fumes or leakage. The wooden portion of the tanks and all materials in the room susceptible to acid corrosion should be protected by acid-proof paint or by a covering that will likewise resist corrosion. Good ventilation should be maintained to prevent the accumulation of fumes.

Lessons of a Power Plant Accident

By H. S. Knowlton

To the operating engineer the detailed study of accidents occurring with electrical or other machinery in a power plant is generally suggestive. There is no question that the careful investigation of service troubles is one of the most profitable practices in which an engineer can engage, but in many cases where breakdowns have happened, there has been little opportunity for thorough analysis of conditions at the time by men experienced in the design and utilization of equipment. The first duty of the engineer is obviously to resume service; later, if time permits, he can make a careful report of the circumstances, and it often happens that such reports are more or less fragmentary.

In the following are given the results of a careful study of an electrical accident in a steam turbine station made by an experienced engineer who was on the way to visit the installation when the accident occurred, and who arrived at the plant within a few minutes after the breakdown. He was not employed by the operating company, and was consequently, at the latter's suggestion, free to investigate the situation without restrictions. The investigation and report indicated the importance of better protection of exciter service and the independent operation of electrical auxiliaries of various kinds, with more regard to the evils of energy reversals between the power plant in trouble and substations connected with it.

The shutdown occurred in a large generating plant in which the relays, speed-limit devices and turbine-speed control as well as the auxiliaries were supplied entirely from the exciter system. A piece of casting of a vertical

turbo-generator became detached and dropped into the revolving member which forced it against the field windings, destroying some and grounding the field circuit. By this accident the entire system of auxiliaries was rendered inoperative. One turbine ran away, and the high voltage generated on part of the system produced disastrous results.

In the retail business district supplied by the company there was a large storage battery floating on the system. This was connected through rotary converters to the generating station and as the direct-current automatic circuit-breakers between the battery and the converters failed to act, the latter were run inverted, thus supplying power to the generating plant and doing considerable damage.

A study of the accident immediately after its occurrence, indicated that the use of an independent source of power for the circuit-breakers alone would not have been sufficient to prevent trouble, because other auxiliaries were involved at the same time and a complicated situation arose. Some of the damage would have been done regardless of the circuit-breakers, although this was, in a great measure, communicated to other apparatus by the failure of the local circuit supplying the auxiliaries.

It appeared that if the switchboard operator in the plant had been able to control the oil circuit-breakers, which were connected in the main circuits between the generators and the busbars and between the latter and the feeders supplying the substations, he might have been able to confine the trouble to the machine first affected.

All the oil circuit-breakers were operated from a gallery overlooking the turbo-generators. If these could have been controlled by a single master switch opening them in an instant, more of the damage probably could have been prevented than had the operator been able to open the circuits by the individual controllers which were in service at the time of the accident. It would have been impossible by the opening or closing of oil circuit-breakers to have saved the first machine, which had its field short-circuited and grounded, but the second might have been protected in this way.

An analysis of operating conditions and the plant equipment indicated that much of the damage was due to the fact that the various auxiliaries which should have come into play were not supplied from a local circuit deriving its power from an absolutely independent source, such as a storage battery. The independent supply should have applied to the turbine governors, which were of the electrically operated type. It also appeared advisable to install automatic relays in all of the lines which supplied power to other systems from the busbars, capable of being set to trip the oil circuit-breakers in case of an excessive overload. In addition proper reverse-current relays should have been supplied in the various substations, which would have prevented the reversal of the energy supply in these circuits supplying power to feed the short-circuits and grounds which existed in the generators. It also seemed essential that speed-limit devices and perhaps reverse-current relays should have been supplied for the rotary converters, so that they would have been disconnected from the whole system when the energy began to flow into the converters from the substation batteries.

It was believed at the time of the accident that the machine not at first damaged supplied power to the short circuit in the armature of the injured generator or to the ground existing in its windings, thus making the damage more serious. At the same time power from the busbars feeding into the armature of the former caused a bad burnout in the armature after the insulation was punctured by the rising voltage. Therefore it appeared that relays operating from series transformers connected on the main leads of the generators would have been a valuable feature, for being supplied from an independent source, and set to operate when there was a reversal of energy, they would have automatically disconnected the generators from the busbars before serious damage had been done.

CORRESPONDENCE

What Reversed the Polarity?

We have two generating units, each consisting of a 26x36-in. Corliss engine driving a direct-current generator. As the load is not large only one set is used at a time.

A short time ago a sudden jar occurred which unlatched the governor. The engine immediately slowed down and would have stopped had not the engineer reset the governor and started up again. Upon going to the switchboard, however, to adjust the voltage, he found that the polarity of the generator had been reversed.

I have often known of a generator running in parallel with another being reversed but have never known this to happen to a generator running by itself. What could have caused such a thing? This unit was stopped and No. 2 started. When No. 1 was put in service again a motor generator set was used to reverse the polarity employing about 100 volts for the purpose. Since then we have had no trouble.

JOHN H. GIBBENEY.

Rowes Run, Penn.

Unequal Air Gap

Last fall complaint was made about a 50-hp. two-phase motor, the owner stating it had no power. Upon investigating we found that the main bearing had worn enough to let the stator strike the frame enough to throw fire, although the coils were not damaged. We took the motor into the shop, removed the copper bars in the motor and insulated them with oiled linen. On each side of the short-circuiting rings were three small pieces of angle-iron to keep the bars from slipping endways on the rotor. These were insulated from the body of the rotor with pieces of fiber.

We then proceeded to rebabbitt the bearings, first putting the rotor in place and blocking it with thin pieces of tin so as to get the air gap equal. The motor was then placed in service and handled its load better than ever. Unless the air gap is equalized, an induction motor will lose power.

G. ANDERSON.

Cresco, Ia.

GAS POWER DEPARTMENT

Diesel Engines at English Country House

By Arthur H. Allen

Many of the ancient mansions which are scattered over the British Isles have been equipped with installations for electric lighting, and the introduction of the tungsten lamp, with its small consumption of energy, has given a great impetus to this class of work. In many cases the generating plant is driven by gasoline engines, which can be managed by the chauffeur of the establishment; but gasoline is too expensive for the larger installations, which, therefore, use oil engines, suction gas plants or, in a few cases, Diesel engines. One of the largest of these installations is that at Stoneleigh Abbey, Fig. 1, the country residence of Lord Leigh, a great part of which was erected 900 years ago, the newer portion having been added in the seventeenth century.

Fig. 1. Stoneleigh Abbey

The installation comprises about 1500 incandescent lamps and a number of motors. The generating plant consists of two Diesel engines of 50 hp. each, coupled direct to four-pole interpole dynamos. The plant is housed in one of the roomy old stables belonging to the estate, which affords ample accommodation. A 10-ton underground tank is provided outside the building for the storage of the fuel, which is Texas crude oil. The oil is pumped by hand to an overhead tank, from which it flows to the engines through filters. As the local water supply is hard, and would deposit sediment in the water jackets, the cooling water is circulated through a cooler, in which an artificial draft is maintained by a motor-driven fan, so that the same water can be used continu-

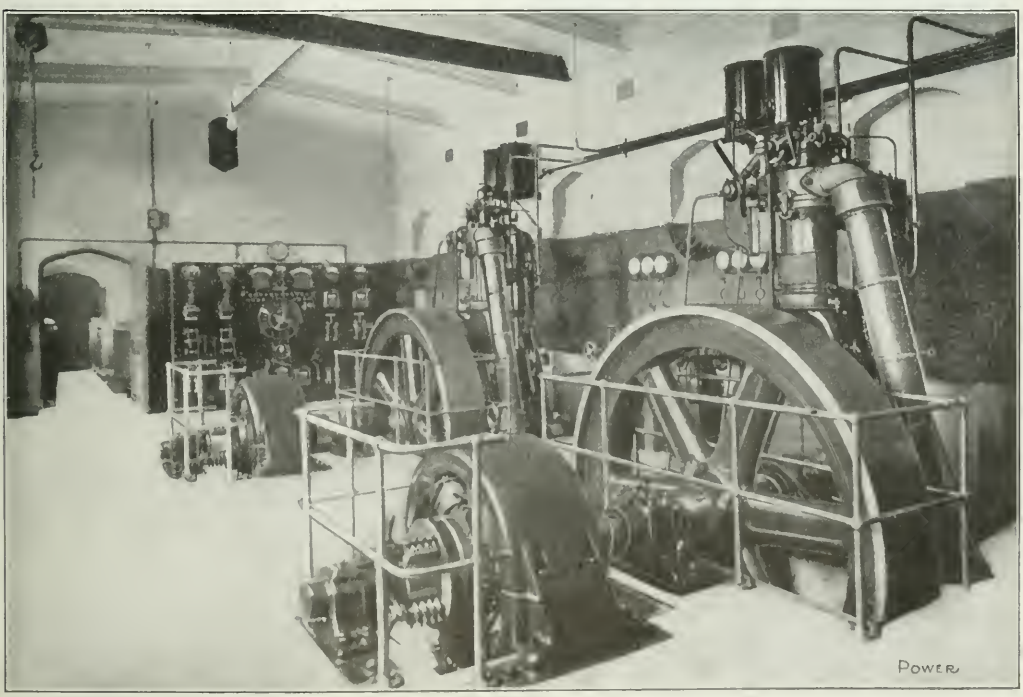


Fig. 2. Diesel Engine Units and Switchboard

ously. The exhaust from the engines is passed into a drum silencer, connected by a short pipe to a second drum, from which it finally escapes through an uptake provided with an expanding head with an inner cone, the result being that the exhaust is almost inaudible.

Fig. 2 shows the generating plant, together with the main switchboard, which provides for two feeders—one to the house and the other to the farm buildings—besides the dynamos and storage battery. The latter, which is situated in the adjoining room, is exceptionally large for a plant of this kind, having an output of 2000 amp.-hr. at the 10-hour rate and 100 volts, and is capable of supplying 900 amp. for short periods. The battery is controlled by an automatic regulator connected to the discharge switch.

The main cables are laid underground, in ducts filled up with bitumen. In the buildings the wiring is inclosed in screwed solid-drawn steel tubing, and the greatest care has been taken to avoid injury to the ancient wainscoting and other woodwork in the Abbey.

Electric motors have been freely used to drive small

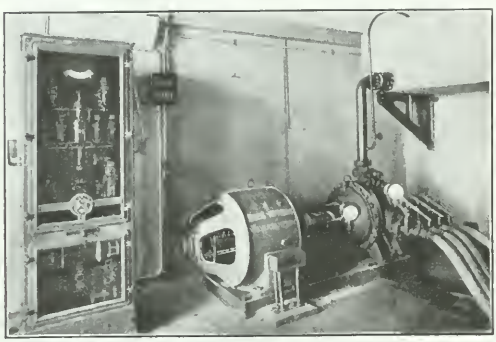


FIG. 3. FIRE PUMP AND CONTROL BOARD

domestic appliances, as well as the organ in the old chapel of the abbey. In the farm buildings, which are also lighted with electricity, motors drive the chaff-cutter and corn-crusher, as well as a large sawmill.

One of the most interesting features of the installation is the fire-pumping plant, Fig. 3. Formerly a steam engine was employed, but it took some time to get this into operation, and a motor-driven pump has now been substituted. The pump is of the Rees-Roturbo type, and is self-regulating, when driven at constant speed. The pump, which derives its supply from the river Avon, is permanently connected to the fire mains running through the abbey and on the roof of the latter, and can throw water over the top of the building; its maximum output is 400 gal. per minute at 117 lb. pressure. It is kept primed constantly by water from the domestic supply. Hydrants are fixed at various places in the building, and at each of these there is a push-button, by which the pump can be instantly started, the switch gear in the pump room being entirely automatic; the full water pressure is available in less than half a minute.

Formerly coal was used for the steam fire pump and the engine driving the sawmill, and oil for lighting; these items cost about $2500 a year, whereas the fuel oil for the Diesel egines, which has replaced them, costs only $125 a year. The installation was carried out by Percy Oliver, of the Midland Electric Light & Power Co., to whom the writer is indebted for permission to publish these particulars.

Cost of Power with Small Gas Engine Unit

By Samuel B. Moore, Jr.

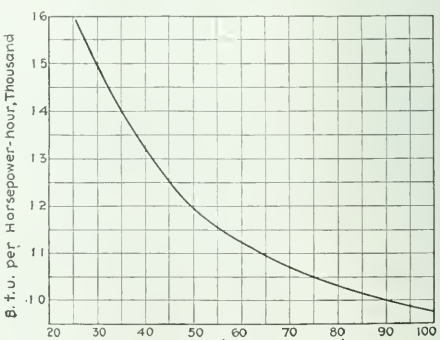
A large and growing industrial concern was recently confronted with the problem of procuring additional power for its plant. An increase of business had necessitated the operation of part of the plant by night, which meant proper lighting facilities. The only lighting means then at the command of the company was gas, but this was not adaptable to their special needs. Electric lighting was imperative; hence the question of purchasing or generating current for lighting arose.

The motive power for the plant was steam, but when the lighting question came up the boiler plant was already operating at its maximum. There were three courses possible: First, to buy current at 8c. per kw.-hr.; second, to install a new boiler (which would mean an addition to the boiler house) and a steam-driven generator, the total cost of installation approximating $4000; third, to install a generator driven by a gas engine at a cost of about $3800.

The last course was selected and the unit was installed. The engine is a three-cylinder, four-stroke-cycle, 65-hp. gas engine, direct connected to a 40-kw., 60-cycle generator, which is capable of carrying 20 per cent. overload. The ignition is of the make-and-break type, the starting current being furnished by a storage battery and the running current by a magneto belt driven from the main shaft. The system is so wired that the current from the magneto always keeps the storage battery charged.

Illuminating gas of about 560 B.t.u. net heat value is used. The engine cylinders are water cooled, and the water outlet is connected to the steam-boiler supply, so effecting economy by using the water twice and utilizing the heat.

To determine whether the engine fulfilled the capa-



HEAT-CONSUMPTION CURVE

city and regulation guarantee of the maker a series of tests was made, the results of which are given in the next table. Two-hour runs were made with one-quarter, one-half, three-quarter and full loads, all measurements of power being determined with a prony brake. As will be noted the gas consumption at all loads is good. The

speed varied between 281 r.p.m. with no load and 274 with full load, thus giving 2.5 per cent. regulation, which is satisfactory.

RESULTS OF TESTS:

Nominal load	¼	½	¾	full
Duration of test, hours	2	2	2	2
R.p.m.	280	280	279	274
B.t.u. per cu. ft. of gas	562.4	558.7	555	561.3
Gas consumed by engine, cu. ft.	954	1350	1865	2270
" " per hour	477	675	933	1135
Net weight on prony brake, lbs.	67	122.5	195	259
Brake horsepower	17	31.2	49.45	64.9
Cu.ft. gas per b.hp.-hour	28.1	21.7	18.89	17.45
B.t.u. gas per b.hp.-hour	15800	12100	10484	9793
Per cent. of rated load	27	48	76	99.8
Temperature of cooling water, deg. F.	186	182	182	187

These values are perhaps more easily compared when presented graphically. The curve indicates the relation between the heat consumption per horsepower-hour and the brake horsepower.

Since installation, nearly one year ago, the plant has been in operation 216 days, with an average daily output of 207 kw.-hr. per ten-hour day, showing a fuel consumption of 6065 cu.ft. of gas per day. The average cost per kw.-hr. is 4.59c. and is arrived at from the following figures:

Gas, 1,310,000 cu.ft. at 80c. per M	$1048 00
Lubricating oil	86.14
Overhead charges	873.00
Repairs	52.76
Total cost	$2059.90
Total output in kw.-hr.	44,712

$$\frac{2059.90}{44,712} = 4.59\text{c. per kw.-hr.}$$

It will be noted that no labor has been included in the cost. This is because the steam-plant engineer operates the gas-engine unit. Inasmuch as it needs practically no attention, his time for starting and stopping the engine is considered negligible.

Producing current even at this rate is cheaper than buying it from the central station. It should be borne in mind, however, that with a daily output of 207 kw.-hr. the engine was run at half load only. Referring to the curve it will be seen that as the load is increased the efficiency will increase. Hence, as the requirements of the business make greater demands for current the cost per kilowatt-hour will decrease until the full load and capacity limit is reached.

[It will be noted that the overhead charges are extremely high—about 23 per cent. of the installation cost. This is undoubtedly due to the inclusion of other items than depreciation, interest, insurance, etc. However, it is significant that, even at this figure, the cost of producing current is less than that for which it can be bought. —EDITOR.]

Loss of Power at Different Altitudes

The December number of *The Otto Cycle* contains the following table showing the loss of power at different altitudes above sea level, expressed in percentage of the power at sea level:

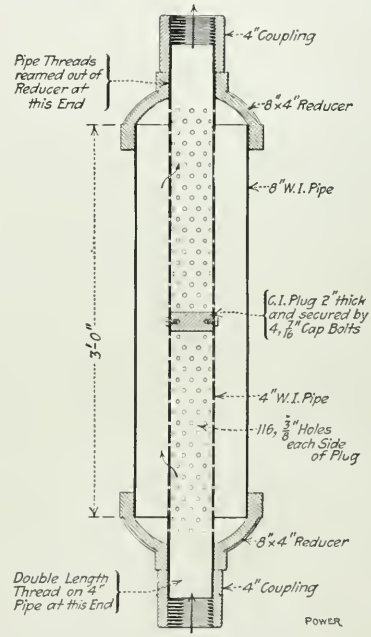
Altitude, feet	Loss in rated horsepower per cent.
1,000	3 55
2,000	6 95
3,000	10 25
4,000	13 45
5,000	16 35
6,000	19 15
7,000	22 35
8,000	25 15
9,000	27 85
10,000	30 45
11,000	32 95
12,000	35 35

CORRESPONDENCE

Exhaust Silencer

A few years ago we decided to use a gas engine to take care of an extra load and purchased a 25-hp. gasoline engine, and, as is the case most medium-sized gas engines, this one came equipped with a cast-iron exhaust vessel. These devices when properly connected, as close as possible to the cylinder, allow the exhaust pressure to drop very quickly and do away with much of the back pressure, but as a muffler or silencer they are not usually of much consequence.

To keep peace with the neighbors, we devised the muffler shown and used it with and connected outside of the


4" Coupling
Pipe Threads reamed out of Reducer at this End
8"×4" Reducer
8" W.I. Pipe
C.I. Plug 2" thick and secured by 4, 1/2" Cap Bolts
3'-0"
4" W.I. Pipe
116, 3/8" Holes each Side of Plug
8"×4" Reducer
Double Length Thread on 4" Pipe at this End
4" Coupling
POWER

SECTION THROUGH SILENCER

cast-iron vessel. It is easily made, not very expensive, is heavy enough to withstand abuse and has proved very effective as a silencer. The exhaust pipe from the engine to the exhaust vessel is 3½ in., and from the latter to the muffler 4-in. pipe is used, the muffler being designed for this size of pipe. The dimensions given are, of course, for this particular case and would have to be changed to meet other conditions. The total area of the small holes in one end (inlet or outlet) should not be less than the area of the exhaust pipe.

M. C. ST. JOHN.

Houston, Texas.

Briquets are said to be an excellent form for using slack coal in a hand-fired plant. They can be burned at a fairly rapid rate of combustion with good efficiency and with practically no smoke. High-volatile coals when briquetted are perhaps as valuable as low-volatile coals when not briquetted.

REFRIGERATION DEPARTMENT

Corrosion in Refrigerating Systems*

As a preliminary the author gave a short summary of the conditions known to be conducive to corrosion, stating previously, however, that the manufacturers of chlorides for refrigerating purposes have been forced to put on the market chlorides that would not tend to accelerate corrosion.

The conditions briefly are:

1. Combinations of unlike metals with the electrolytic brine.

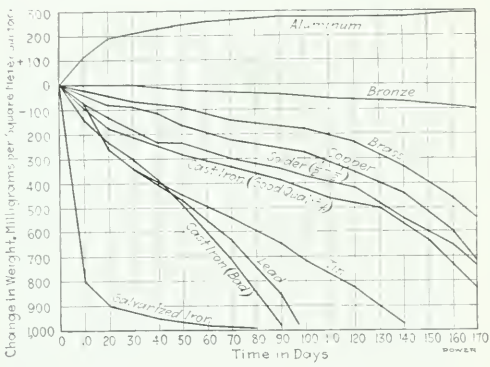


FIG. 1. SINGLE METALS IN CALCIUM CHLORIDE BRINE, SPECIFIC GRAVITY 1.2

2. Combinations of the same or like metals in brine, but of varying degrees of purity, and segregation of impurities.

3. Metal in a state of strain, especially torsional stress.

4. Cutting effect of heavy brines when forced at high velocity through short-turn bends, or through piping of too small diameter relative to the volume of brine carried.

5. The presence of air (oxygen) in the piping, or other apparatus, or in solution in the brine itself.

6. Faulty construction of the brine-carrying apparatus so that the brine originally free from air or relatively so, soon becomes saturated with air (oxygen) and, in consequence, highly conducive to corrosion.

7. Comparatively high brine temperatures which are relatively conducive to corrosion, compared with lower temperatures.

8. The action of electric currents through refrigerating systems, especially the brine-carrying parts.

9. Actual contact with electric current-carrying circuits due to faulty installation of wiring, conduits, etc.

10. Leakage of electric current from poorly installed metallic conduits, which are neither grounded nor insulated from their supports.

11. Poor quality of metal used in the brine-carrying parts of the system, especially in the case of cast iron used in headers, pumps, etc.

12. So-called protective coatings, which in many cases actually accelerate corrosion, rather than inhibit it.

13. Galvanized iron of poor quality, which resists corrosion very well for a short time until the zinc has been dissolved away sufficiently from the iron to extend beyond the limited zone of protection from corrosion. Only the very best grade of galvanized iron should be used, since it is well to bear in mind the evidence that the iron used for galvanized iron is seldom of good quality; and so, once the zinc has dissolved so as no longer to protect the iron, the iron itself will almost invariably be attacked very vigorously.

To show the behavior of metals in brine, tests were conducted covering not less than 100 days—in some cases a year or more—to allow full time for the reactions. The metals, were only seven-eighths immersed in brine, as this simulates a condition very general in practice. The test pieces were $3\frac{1}{2}$ x $1\frac{1}{4}$ in. in size. The brine was renewed every seven days. The change in weight of the metals was noted at frequent intervals, and calculated in terms of change in weight per unit surface exposed to the action of the brine. The results of such tests on single metals are shown in Fig. 1, the curves representing the general or average behavior of the respective metals in calcium brine at about 13 deg. F.

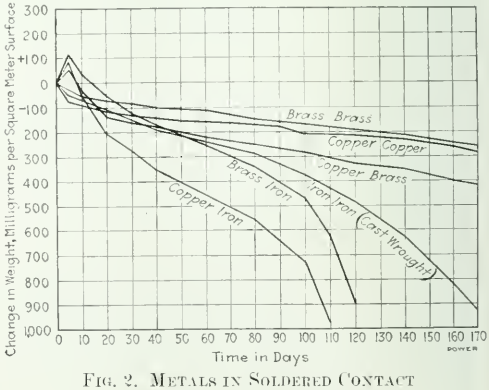


FIG. 2. METALS IN SOLDERED CONTACT

The peculiar behavior of aluminum is characteristic of this metal in a number of solutions and is apparently due to the accumulation of a strongly adherent coating of oxide. Aluminum actually gained in weight on this account.

The alloys seem more resistant to corrosion than do the metals of which the alloy is composed. This is seen in the behavior of bronze and solder.

*Abstract of paper read by Morgan B. Smith before the American Society of Refrigerating Engineers, New York City.

In galvanized iron the great loss during the first ten days' immersion is due to loss of zinc, during which period almost no iron went into solution. At the end of this period there was not sufficient zinc remaining to further protect the iron, with the result that iron began to dissolve along with the remaining zinc. The reaction then gradually assumed the same characteristics shown by the iron of good quality. It is evident that the galvanized iron used in these tests had very good iron as the base.

The figures shown on the chart are not absolute quantitative results, but are merely comparative, under the conditions maintained in the tests. Different conditions might readily alter the comparative results, although those given are fairly representative of the behavior to be expected of the respective metals in brines of any description.

A similar chart was made up for a series of dissimilar metals in contact in brine and a third chart for aluminum combined with several unlike metals and immersed in brine. A fourth chart, reproduced in Fig. 2, shows the results from a number of metals soldered together. The solder seemed to exert an effect similar to that shown by the zinc of galvanized iron, inasmuch as the solder went into solution in each case. The reaction on the metals other than solder was slight, compared with the effect on the solder. The combinations of dissimilar metals show much greater losses than do those of similar metals. These tests were of nine months' duration, only 170 days' tests being shown on this chart, since the general results are well defined during this period. The brass-iron soldered couple continued to show less loss than did the copper-iron soldered couple in these tests.

The gain in weight shown by the brass-iron, the copper-brass and the copper-iron couples was probably due to an accumulation of weakly adherent oxides, possibly due to air (oxygen) in the brine, which was soon used up, after which oxidation was not manifest even on repeated renewal of the brine. The net result of all these tests was to prove that even under the best conditions some corrosion may be expected when single metals, or combinations of dissimilar metals are immersed in an electrolyte such as brine.

Some of these tests were carried out with the metals completely immersed in the brine, the fact being brought out that the losses, when the metals are only partially immersed, are roughly ten times as great per unit of time as when the metals are completely immersed. This only bears out in a striking manner the facts noted in practice, namely, that air (oxygen) must be kept out of the refrigerating system just so far as is possible. Brine-containing apparatus and piping must be kept completely filled with brine, so that air cannot accumulate in high parts of the apparatus. Wherever air does accumulate corrosion will manifest itself sooner or later.

In order that the effect of electric currents, when sent through a system composed of two dissimilar metals in brine, might be noted, tests were made using electric currents of low potential, and of almost no amperage. The effects of very small currents were in proportion to their magnitude, as was expected, the main point brought out being that currents showing a potential as low as one millivolt actually hastened corrosion. The fact was driven home that engineers in charge of refrigerating plants, in their tests for leakage of current, were missing the very currents which in many instances were causing remarkable acceleration of corrosion, if not actually starting the reaction.

Tests for stray electric currents must be made with instruments capable of detecting extremely small differences of potential. It is at local points of increased potential that trouble is likely to appear, due to one or more of the following common sources:

1. Electric motors and generators not properly grounded.
2. Electric motors direct connected on a common shaft with a centrifugal brine pump, and not insulated from the pump in any way.
3. Suspension of electric lamp wiring, frequently for incandescent lighting, and often for arc lamps, directly from the brine lines or other brine-carrying apparatus.
4. Electric wires carrying heavy currents in contact with the apparatus in such a way that the insulation is often completely rubbed through at the point of contact.
5. Electric wiring, such as annunciator circuits, carrying only currents of momentary, small magnitude, but which, through frequent recurrence, often give rise to pronounced action.
6. Poorly installed metal conduits from which current frequently finds its way into the brine lines, etc., as noted above.
7. Sources of current entirely foreign to the refrigerating plant as trolley circuits, arc light circuits, telephone circuits, etc.

*

Ammonia Compressor Safety Devices*

By Peter Neff

Safety devices for compressors may be divided into those which provide protection against accidents resulting from breakage of parts which go to make up the entire compressor, and those which provide against damage resulting from other than inherent causes. The first class provides against such accidents as the breaking of valves, rupturing of cylinder walls and heads, breakage of piston rods and rings, and the like. The breaking of the valves in the early days was probably the greatest source of damage to compressors, but this defect has to a large extent been eliminated by making the valves from a grade of material which does not so readily tend to crystallize, by constructing the valves so that they are more or less cushioned in their operation, by locating the valves so that the broken parts remain in the pocket in which the valve operates and cannot enter the cylinder, and by the use of a false head in the compressor, covering the entire bore, which is held in place by springs of greater tension than the pressure ordinarily exerted on the head. This method is not applicable except in vertical single-acting compressors.

The second class deals with such accidents as are caused by explosions, unusual pressures, the presence of liquid in the compressor and the like. The best guard

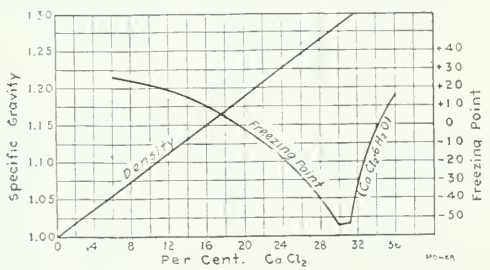
*Abstract of paper read before the American Society of Refrigerating Engineers, New York City

against explosions is judgment and care on the part of the operator. When a machine is started with the discharge valve shut, failure may not take place in the compressor, but in some weaker part of the machine. To avoid this insert a relief valve in a bypass between the discharge and suction sides of the machine. If this device is not used it tends to become useless, and when used too frequently is apt to leak. This method, notwithstanding its faults, seems to be the best available at the present time, and should be improved along the lines of better seating and a better arrangement for operating by hand, so that it can be tested daily.

For protecting against the presence of liquid in the compressor the false head applicable to vertical single-acting compressors would seem to be all that is necessary, but the construction detracts to a large extent from the usefulness of the cooling water, owing to the gaseous space between the false head and the head proper. In small compressors where the discharge valve is of the same diameter as the compresser, satisfactory and safe results are obtained.

Making Calcium Chloride Brine

In the Nov. 5 and the Dec. 3 numbers of POWER I noticed articles on the making of calcium chloride brine by C. E. Anderson and R. A. Cultra. With regard to the method followed in making up this brine I wish to call attention to a very satisfactory manner of dissolving the chlorides. In the brine tank, at the end opposite the outlet, is built a suspended grating of wood or iron with holes about ½ in. in diameter. This grating should be submerged to a depth of at least 12 in. On this grating is placed the chloride, preferably broken up,



DENSITIES AND FREEZING POINTS OF CALCIUM CHLORIDE

although in some cases the whole block from the drum is set on end upon this grating. Into this grating the return brine empties below the surface of the brine, because of the danger of saturating the brine with air.

With such an arrangement the chloride will dissolve rapidly and no large chunks can possibly go to the bottom of the tank there to form a hard mass which will not readily dissolve. There should be, of course, some circulation in the tank to facilitate solution of the chloride and to provide a uniform brine.

Mr. Cultra says that the greater the density of the brine the better, as a much lower temperature can be maintained in the refrigerators, if so desired. This statement is somewhat deceiving, as with calcium chloride there is a limit to which the density of brine may be carried. The relation between specific gravity, freezing points and percentage composition of calcium chloride brine is shown in the accompanying table and in the chart which shows the same relations graphically.

Sp.Gr.	Freezing Pt. deg. F.	Per cent. $CaCl_2$
1.05	+26	6
1.07	24	8
1.087	22	10
1.104	18	12
1.133	15	14
1.143	10 5	16
1.164	4.5	18
1.183	— 3.0	20
1.202	—10.0	22
1.222	—19.0	24
1.242	—30.0	26
1.263	—42 0	28
1.285	—54.0	30
1.295	—53 0	31
1.305	—32.0	32
....	— 6.5	34
....	+16.0	36

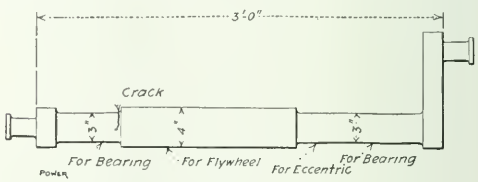
After reaching a density of approximately 1.285, any further increase means a rise in the freezing point. These extreme densities are not reached in practice, but I know of several instances where engineers in charge have gotten into serious difficulties because they have allowed their brine to become too heavy in chlorides, with the result that the brine congealed at the working temperature and caused no end of trouble.

M. B. SMITH.

Detroit, Mich.

A Broken Crankshaft

We have a 10-ton, single-acting, steam-driven compressor running at about 100 r.p.m. Ever since this machine has been installed (about one year) we have



SHOWING LOCATION OF FRACTURE

had trouble with the crankshaft bearing on the compressor side of the unit. Sometimes it would run fine for a week and then the bearing would get hot from no apparent cause. At times it would not take more than 15 min. for it to get hot enough to slow down the machine and then again it would gradually warm up and keep getting hotter for a whole day. Everything we could think of was done, but with no success.

One morning while sitting at the desk I noticed the compressor begin to slow down. Upon going over to the machine I found the bearing almost hot enough to melt the babbitt, and it had been cool only 10 min. before. Feeding it with oil did not help any, so I decided to loosen up on the bearing cap. I had backed the nuts off about one-half turn when the compressor side stopped and the engine began to race. After stopping the engine and taking the cap off the bearing, I found that the crankshaft had broken at the shoulder formed by the body of the shaft with the bearing journal. An examination after removing the shaft showed an old crack and that there had only been about a square inch of metal holding the shaft together.

J. H. STRETTON.

Los Angeles, Calif.

EDITORIALS

Heat Balance in Steam Boilers

It is not enough to know that a boiler evaporates a certain number of pounds of water per pound of coal, even when this performance is reduced to a common basis of "from and at 212." It is not enough to know that sixty per cent. of the heat in the coal has been absorbed by and is present in the steam. The engineer who is going to profit by a boiler test wants to know what became of the other forty per cent. and why that is not in the steam too.

The way to find this out is to make a heat balance; to put upon one side all of the heat furnished to the boiler in the coal and upon the other the amount absorbed and used in making steam, that not developed as a result of incomplete combustion, as by gases going off unburned, coal dropping into the ashpit, etc., the heat carried off through the stack by the hot products of combustion, the heat taken out with hot ashes, clinker, etc., the heat used to evaporate moisture out of the coal and heat it to the chimney temperature, the heat lost by radiation, etc. If one can learn through which of these channels the unabsorbed heat is escaping he may be able to save at least a part of it.

The making of a heat balance has been a difficult and complicated operation, involving an ultimate analysis of the fuel as well as exceptional precision in the determination of the more frequently observed quantities in a boiler test. On page 42 *et seq.* is an article from the pen of Professor Marks, one of the authors of the Marks-Davis steam tables, which shows how such a balance can be made with an accuracy which is within the attainable degree of accuracy of a boiler test itself without having recourse to the ultimate analysis. The article not only explains how the various quantities are determined and calculated but gives diagrams by the use of which much of the calculation is avoided or simplified.

Use of Fuel Oil

While the use of fuel oil for generating steam has made great progress on the Pacific Coast and in other sections having low transportation rates from the Southwestern oil fields, the advantages of liquid fuel have not been realized in many localities because of the dearth of practical information among engineers on the subjects of oil burners and the arrangements of furnaces best adapted to the combustion of liquid fuel. Very creditable contributions have been made to this branch of steam-engineering literature by California engineers and others through the transactions of the American Society of Mechanical Engineers, which give valuable information on the subject.

But a more general introduction of fuel oil need not be looked for until the rank and file of operating engineers and firemen are made better acquainted with the requirements of liquid fuel burning with respect to storage, safety, designs of oil burners, value of different kinds of oils and modifications of present coal-burning furnaces which are necessary to the successful use of liquid fuel.

It would seem that there is room for good practical literature on the subject of oil burning and it is suggested that if the oil trade looks forward to business in this line, it could not do better than to study conditions in different localities, and supply power-plant engineers with practical information on oil burners and boiler furnaces for burning oil under different types of boilers, together with suggestions of methods of adapting the leading types of boiler furnaces to the employment of liquid fuels.

Testing Auxiliary Machinery

Power-plant testing is recognized by most engineers as essential to economy. The prevailing tendency, however, is to confine such tests to boilers and engines, allowing the small auxiliary units to run without knowing definitely as to their condition or efficiency.

For instance, a duplex steam pump, such as is commonly used as a boiler feeder, is exceedingly wasteful of steam when compared with an automatic cutoff engine. The pump does not use as much steam as the engine during a day's run, but the steam consumption per horsepower developed is much greater. It is seldom, however, that power-plant pumps are given a test run. They have been known to operate for years with the steam valves leaking so badly that the exhaust pipe showed a continuous discharge of steam while the pumps were being operated.

Other causes for a pump not working at its full capacity, even if the steam valve and pistons are tight, are scored water cylinders and worn water packing. When pumping against a pressure some of the water leaks past the piston to the other end of the cylinder and, to handle the required amount of water, the pump must be run enough faster to make up for the excessive slippage.

This is wasteful and steam is consumed to push a plunger that is displacing but a part of its maximum capacity. A little attention on the part of the engineer would disclose the waste, when steps could be taken to remedy it.

It is not uncommon to see the vacuum gage of the condenser registering only twenty-four inches. If the gage is correct there is something wrong with the condenser. If a higher vacuum is not carried, say twenty-six inches, then the economy of the engine is reduced according to the difference between the vacuum that is and the vacuum that should be maintained.

An incorrect gage is a defect easily remedied. If the trouble is in the condenser the engineer's first duty is to test it out, ascertain if the supply of cooling water is being interferred with, how the vacuum and temperature check and examine the valve gear of the condenser; the plunger may be making but a partial stroke.

It is not the larger leaks which cripple a power plant, for they are easily detected and the engineer is forced to remedy the evils because they are so apparent, but the small leaks which exist week in and week out, out of

sight and undetected, eat into the plant economy to a much greater extent than most engineers realize.

One small source of leakage may not amount to much in itself, but a number taken collectively are equal to one large leak that would not be allowed to exist in any except a grossly mismanaged plant.

The Value of Tact

That tact is valuable is so evident and universally acknowledged that it scarcely seems necessary to comment on it. However, the very commonness of the desirability of possessing and exercising tact is probably accountable for its being so frequently overlooked. Ask anyone if he has ever known instances where tact has benefited the possessor, or the lack of it worked to the disadvantage of the one devoid of it, and he will immediately recall innumerable such instances. Nevertheless, this same person, within a very short time either before or after the conversation, himself might have committeed an act that indicated a failure to appreciate the value of tact. What is the explanation? Simply that it is a human trait to lose sight of the most obvious things.

Without going into the citation of numerous incidents illustrating wherein tact has profited someone, or its absence accomplished the reverse, only one very ordinary experience will be mentioned. This occurring but a few days ago, brought the subject freshly to mind, hence this dissertation.

A manufacturing plant was in need of the services of an operating engineer. A capable, likely man applied for the position. Looking over the plant he saw ways in which he could improve the plant and both he and his prospective employers were confident of his ability to handle the situation. It so happened that the previous engineer had not been as competent as might have been desired and in consequence the company had engaged a supervising engineer to inspect the plant and recommend changes in its equipment and methods of operation that would make it more economical.

The plant was in immediate need of a new operating engineer so that the factory might continue operation, for it was the busiest season of the year. The applicant for the place agreed to take it, but later, finding that the supervising engineer was not instantly withdrawn, refused to go to work. In short, he quit before he actually started work, in spite of the fact that the company had agreed to dispense with the supervising engineer as soon as it could gracefully do so.

Naturally a self-reliant man feels no need of an outside advisor and may even resent what seems to him as interference. Equally natural is it for the management of an institution to hesitate about cutting itself off too hastily from its previous best help until it is reasonably certain that the substitute contemplated is likely to be satisfactory.

One may say that this engineer showed a lack not only of tact but of good judgment. It would have hurt his reputation not at all to have operated the plant for a season in coöperation with the advisory engineer and without question, he would now be in a good position. Instead he is still out of work and the plant to which he had agreed to come was compelled to lie idle at a very inopportune time. While much may be said on both sides of this case in justification of the course each party pursued, the fact remains that bitterness was engendered, and that the reputation of the engineer is quite likely to have been injured; worst of all is that more tact on either side might have brought about a favorable conclusion.

To realize the most from it, tact must be an innate quality of the man. Unless it comes natural to him he will surely forget to use it when the need arises. False pride and hot-headedness are foes to tact. The man who has no predisposition to the latter should strive the harder to develop it, and in the meantime to subjugate the antagonistic tendencies.

Their Mutual Obligation

The recent holiday season has brought into notice a decided tendency on the part of both employer and employee to give each other credit for acts performed outside the narrow line of duty. This tendency will do much to make their respective positions understood, and when more widely practiced, it will be a power for much practical good.

We do not believe that the giving of money or presents as sufficient recognition of the employee's merit or long service is wholly actuated by selfish motives or by a desire of the employer to pose as an almsgiver or as a philanthropist. Many industrial concerns today have rightly concluded that their success has largely depended upon the skill and interest displayed by their employees, and have therefore chosen the holiday season as a fitting time in which to give this recognition substantial expression. And they are, in a measure, practically canceling a business obligation.

For many years the relations between capital and labor were narrow and distrustful, but now their growing knowledge of mutual dependence has given each a broader, more disinterested view point and created a human-interest element hitherto lacking. This is as it should be.

Undoubtedly the demand for workmen of high intelligence and quick, sound judgment to operate the high-powered, often intricately constructed machines now in use has caused to be superseded the workman with more muscle than brain. Because of this fact, we believe that both capital and labor are adopting a plan whereby each will get the best that the other has to give.

Therefore, we say it is obligatory that capital give its fair meed of praise and compensation to labor, and equally obligatory that labor strive to serve capital's interests with something in mind beyond the mere dollars-and-cents return expected.

The *Kansas City Post* prints illustrations, accompanied by the usual photograph of the inventor, of a wonderful engine, patented and perfected by B. F. Goldsborough, of Joplin. This engine is expected to "save 74 per cent. of the heat used instead of three per cent., as is the case in a common engine, or eight per cent. from a superheated engine." Inasmuch as the better of the present engines convert over 70 per cent. of the heat available in the temperature range through which they work, into mechanical energy, it would seem that Mr. Goldsborough has performed quite a feat, if, as the papers says, his first engine, one of 225 horsepower, has been made and sold, and is a success.

READERS WITH SOMETHING TO SAY

Points about Steam Traps

This letter sets forth the principle reasons why steam traps often fail to perform their duty satisfactorily. There is probably no piece of apparatus around a steam plant that receives less attention and yet has more expected of it than the steam trap.

Failure of traps to operate successfully is often due to one or more of the following causes. First, the trap has not been properly installed. Sometimes the discharge is choked, due to faulty piping, such as too many ells, tees, etc. The discharge should be as straight and free as possible and of the full size of the outlet of the trap. Also in regard to pipe fittings, I have found that the more liberal use of 45-deg. ells and Y's in all piping of this kind gives far better results than 90-deg. ells and tees. Fig. 1 shows right and wrong connections and clearly illustrates the value of the 45-deg. ells and Y's. The trunk lines are shown at *A* and the branches at *B*.

This piping question is one that deserves considerable study and attention because a little careful planning in the beginning will save a lot of expense, work and

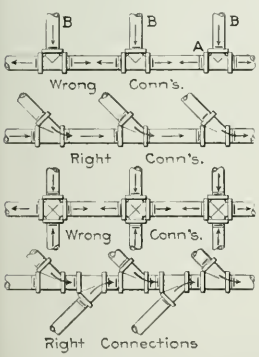


Fig. 1. Right and Wrong Trap Discharge Pipe Connections

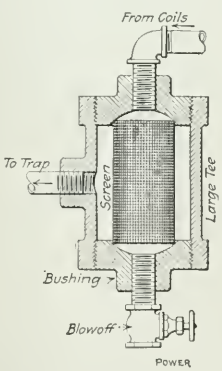


Fig. 2. Strainer for Trap

worry, when the installation is completed and will often give results far above the average. Another very important thing which seems to have been overlooked in most cases is to see that dirt and other foreign substances are prevented from getting into the trap and putting it out of commission by plugging up the valve. Some will purchase the finest and most expensive trap and then connect it up to dirty coils or other apparatus before the system has been blown out, and neglect putting any kind of a strainer in the inlet to the trap. Fig. 2 shows a very simple strainer that can be made of pipe fittings and a piece of heavy brass or copper wire screen made in the form of a cylinder so that it will fit into the recess in the bushings.

A trap of the first order is the simple expansion trap and while there are various modifications of it, we will only deal with it in its simplest form. This trap is made of a piece of brass pipe of suitable size and length, mounted in a suitable frame. One end of this pipe is connected to an adjustable valve, while to the other end is connected the return from the steam coils or other apparatus that is to be drained. The operation is as follows: When the water is all blown out and the trap contains only dry steam, the valve is adjusted so that it is just closed, but as the trap fills with water, it causes the brass pipe to contract or shorten in length and by doing so the valve is opened and the water is discharged. The action tends to clean the valves.

Very evidently if this trap is regulated to suit a certain pressure, it may not operate perfectly at some other pressure, because there will be quite a variation in the temperature; this I have found to be the case from actual experience. Then, too, this type of trap will not always take care of a sudden rush of water because there is not always sufficient area in the valve, so we find that while the expansion trap is one of the simplest and most sensitive forms of trap, still to give good results the conditions must be as near ideal as possible, that is, the steam pressure must not vary too much and the flow of the condensate to the trap must be fairly steady and not more than the trap can take care of. I have found that this trap operates best when it is set in an inclined or vertical position with the outlet valve at the bottom because, in this position, as the water rises and falls in the tube, the expansion and contraction is more uniform and there is always a water-seal over the valve.

George J. Little.

Passaic, N. J.

Troubles of a Feed Water Heater

Where I am employed a new feed water heater has just been installed, and as it at once gave trouble I began a close observation of its action and have found the following faults which may be of interest to others. I might state that the heater was bought without any recommendation on my part.

The boiler at this plant is 48 in. by 15 ft. The heater is 42x100 in. and of the open type. The heater is much too large for the boiler and as the water does not move through it fast enough it loses its temperature. Proof of this lies in the fact that if I run the boiler feed pump quite fast for a few minutes, I get a temperature above 200 deg. F., but when the pump is run at a steady speed thereby keeping a steady water level, the temperature of the feed water falls to about 190 deg. F. Now if the heater was smaller the water would move faster and I would get a higher feed-water temperature.

In the heater a vertical partition divides the lower half into two sections, one is the settling chamber and the

other is the filtering chamber. The raw feed water, as in other makes, enters at the top and flows over a number of trays, mixing with the exhaust steam, and then falls to the settling chamber.

From the settling chamber it goes to the under side of the filter and works up through it to the top where the pump suction enters the heater. From the bottom of the heater to the pump suction is 4 ft. From the pump suction to the overflow is 14 in. If the water supply line should give out I now find that while I have 4 ft. of water below the pump suction there is only 14 in. of available water.

The lower end of the regulating float chamber is connected into the pump suction line and, as soon as the pump is started, water is drawn from the float chamber and the supply valve opens at once.

While at first this seems a good plan, still it does not work out well. It takes some time for the water to work up through the filter; the cleaner the filter the shorter the time. When the filter gets dirty and works slowly the boiler feed pump lowers the water supply on the filtered side very fast and the supply valve is opened wide. Then there is an inrush of raw water which the filter cannot handle fast enough so that the overflow is worked to the limit and the supply of hot water goes to the sewer.

As to the filter itself. If a person is using a real good feed water maybe the filter would not give trouble for a long time after it was properly cleaned. I am using water containing 33 gr. per gal. of solids and the filter becomes so badly choked up in three weeks that I cannot get water through it fast enough to supply the boiler. The material used in the filter is coke with a piece of course burlap at the top and bottom.

W. A. Flannery.

Waukesha, Wis.

[Mr. Flannery's letter seems to indicate that the troubles mentioned are not due so much to improper design of the heater as to the manner in which it is installed and also because the feed water is very high in solid content. Perhaps interested readers can suggest remedies for Mr. Flannery's troubles.—Editor.]

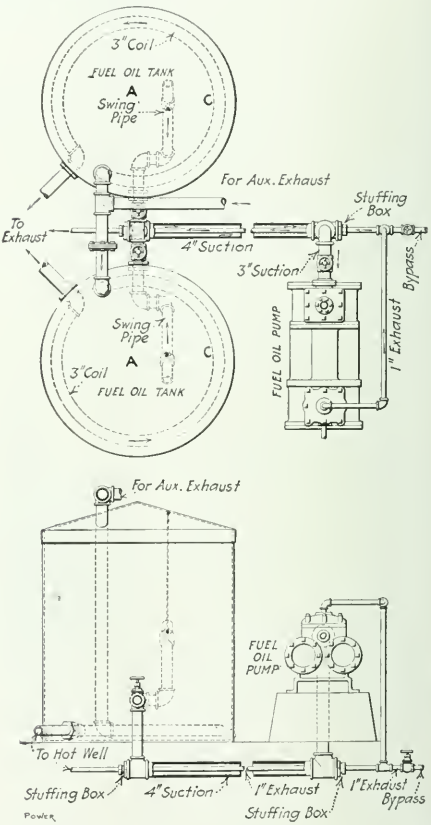
Heating Fuel Oil

The heating of fuel oil to the proper temperature is at times quite a problem, as during the cold weather when the boilers are already overloaded and the fuel consumption is high. I believe we have the problem solved for plants that are operated noncondensing. We use fuel oil of 14 deg. Bé. which is very stiff at 60 deg. F. and apparently gives the best results when heated in the tank to 120 deg. F., allowed to stand at that temperature about four hours (which gives time for most of the moisture to settle) and then heated in a closed line to 140 deg. F. before it reaches the burners.

To get this temperature we use the equipment shown in the illustration.

The two fuel oil tanks *A* and *A* are of 100 bbl. capacity each and each has a 4-in. suction line with a swing pipe which may be hooked to take oil from any desired depth in the tanks. The oil follows the arrows to the fuel oil pump which is a duplex 4½ and 2¾ x 4 in. with a 1-in. exhaust, which, as shown, is connected with a bypass and also through a stuffing-box into the 4-in. oil suction line through the center of which it passes for about 49 ft. and out the other end through another stuffing-box and then on to the hot well.

Each tank contains a 3-in. coil *C* into which exhaust steam from the feed water pumps, etc., is allowed to enter at the top of the tank. It passes down the standpipe around the coil and out at the side to the hot well. This pipe is connected with the lines to an open feed water heater so that any desired amount of the exhaust steam may be used. The coil heats the oil in the tank



Tank, Pump and Connections for Fuel Oil Heater

enough to settle the moisture, but not enough to cause a loss by vaporization. After the oil has entered the 4-in. suction and is on its way to the pump it may be heated to 140 deg. F. or even higher without a loss of the lighter oils or distillates, with this equipment we get the oil through the pump at 140 deg. F. and take out basic silt and moisture to the extent of 0.1 to 0.4 per cent.

B. F. Hartley.

Quail, Calif.

[This fuel-oil heating outfit may be made by the plant engineer at a cost little above that of the tanks, as the necessary pipe and fittings are always available.—Editor.]

QUESTIONS BEFORE THE HOUSE

Buckling of Boiler Tubes

In the August 27 issue, Mr. Davis goes to some length explaining how and why boiler tubes buckle, but in my opinion his ideas were not obtained by actual contact with working conditions.

Actual inspection of hundreds of boilers has taught me that his statement that water tubes always bend upward is misleading.

I have seen water tubes that bent upward but generally the buckling is downward for the very good reason that the bottom of the tube, being nearer the fire, expands more than the top, therefore the bottom of the tube is slightly longer and the tube is compelled to come downward to accommodate this unequal length. Then take, for instance, the common types of horizontal water-tube boilers which have tile covering the upper half of the tubes, these tubes always buckle downward because the fire does not get to the top of the tube and consequently the lower half expands more.

To the engineer who has ever undertaken to prevent a piece of iron or steel from expanding when heated, Mr. Davis' suggestion that scale in a water tube will hold it so tightly that it cannot expand, will seem ridiculous; really it is preposterous to propose that a quarter or even half an inch of boiler scale will have sufficient tensile strength to withstand a force of nature that was used by the ancients to straighten up heavy walls which had got out of plumb. That was done by bracing them up tightly with cold metal and applying heat, causing expansion and the wall had to go back in place.

The experienced engineer has always found that all scale was cracked off a boiler plate or tube which had been overheated.

The statement that tubes in return-tubular boilers either bend downward or loosen at the ends is also near-erroneous.

If Mr. Davis wants to try it just let him have a sleepy-headed fireman let the water down in the boilers so that a couple of inches of the upper tubes are above water line and if they do not bend upward it will be the first case I ever heard of in which they did not. To get a positively heterogeneous style of buckling let him try opening up a blow-off valve and be unable to get it closed again, a good fire under the boiler meanwhile, then when he looks into this boiler he will find buckling toward every point of the compass.

With water at its proper level in a horizontal-tubular boiler a tube rarely buckles, no matter how much scale it has on it. Tubes in a horizontal-tubular boiler are not in the least partial as to which side collects the most scale, it is usually deposited evenly all over the top and bottom alike but I have met with numerous instances where the scale was much heavier on the bottom of the tube than on the top and when a tube gets enough scale to cause overheating it simply expands evenly all around and either bulges the head or slips in the hole.

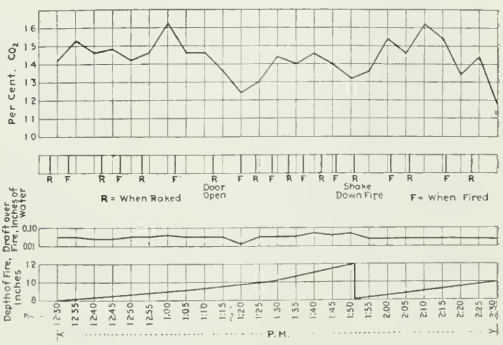
Meanwhile I must confess that I do not know nearly all there is to be learned and would like to hear from others on this, to me, very interesting subject, particularly from those who, like Mr. Davis, have a kind of boiler scale that is so tenacious that neither fire nor expansion will loosen it.

C. R. Summers.

Chattanooga, Tenn.

Results in CO_2

The letter under the heading "Results in CO_2," in the issue of Sept. 10, corroborates the conclusion I reached some time ago. Such results cannot be arrived at as we determine engine performances, by the analysis of indicator diagrams, for unlike engine performances, furnace conditions and the human element are constantly changing in boiler practice. However, the nearest approach



Showing CO_2 Variation with Different Conditions of Fuel Bed

that I have discovered for presenting the result graphically is by means of a chart as shown.

The chart covers a period of two hours. The explanation is as follows: Each square represents a period of 5 min. Thus at 1:05 p.m. the CO_2 was 14.6 per cent., the draft over the fire 0.05 in. of water, and the depth of the fire (apparent) was 9 in., three minutes after charging the furnace.

Taking the average for the day of 11 hr. by means of a gas collector and the Hays instrument, gave a result of 12.4 per cent. CO_2 which checks up quite accurately, considering that the collector was working continually during periods of opening furnace doors, cleaning fires, etc.

The evaporation per pound of coal as fired from and at 212 deg. was 9.22 lb.; unfortunately, this figure is lower than usual.

Upon looking over our records of this boiler I find that the last analysis of the flue gases made for deter-

mining the per cent. of CO_2, CO and O upon the following dates showed:

No. 2 BOILER.

	CO_2 per cent	CO per cent.	O per cent
July 12	11	0.04	6 2
" 13	11	0.08	6 2
" 15.	10 2	0.4	7
" 16.	10 6	0.6	6 8

The results are very satisfactory, considering that the boiler is operating at a 50 per cent. underload.

GEORGE C. J. SPANGENBERG.

The Attitude of Many Employers

In a recent editorial in POWER there appeared the statement that the engineer was considered as a necessary evil. With respect to a factory it is useless to say that the engineer is indispensable to the owner and not pick out many other department heads without which the articles manufactured by that particular firm could not be produced. In the same way it is evident that if there was no factory there would be no engineer and so we might go on indefinitely with such conclusions.

The main question is, why should the engineer be a necessary evil any more than the workmen in the shop, for every manufacturer expects to have tools and machinery and most of them expect to have power, and the output depends greatly on the manner in which that power is maintained.

It does not seem reasonable in these days that many employers would think that their engineer need not be a man of considerable intelligence to operate the machinery in a safe and economical manner. Nor do I see where any manager would be justified in making the remark quoted in the editorial that he always knew that it meant some expense when he saw the engineer approaching, unless the employee was unusually careless and negligent.

It has seemed to be usually the case where the owner has a fine modern power plant that he is always glad to show it to his friends and his associates in business and why then should he regard the men to whom he has intrusted the care of this extremely valuable property as necessary evils? The broad-minded employer does not have this feeling if he sees that his engineer takes the proper interest in his work. It is necessary that the engineer try to explain everything to his employer, so that the latter may take the same view of the affairs of the plant that he does and if this is done, there should be harmony between them.

One thing that tends to bring discord between these two is that the engineer does not work by that clock-like regularity as regards the different jobs that he may do each day, as do the workmen in the shop. With them it is an effort to turn out the largest amount of good work in a given time, which is called quick production, while the engineer's part in good production lays in the regularity of service that he makes his plant give and to promote that regularity he may have this part to repair on one day and that on another. In the meantime there may be intervals of apparently idle moments or whole days of very little manual labor, which being observed by the employer, give him the feeling that there is a lazy man in his engine room.

If this conclusion is true, then the operation of the plant will sooner or later show it, but if the appearance of the plant continues to be good and the expenses do not show any unusual increase, the employer should feel that the engineer is doing as well as can be expected.

Another very fruitful cause of trouble is the tendency of some employers to try to make the engineer feel that they "know it all" as many of them do by offering suggestions on how to run the plant. I have been thrown in contact with men who should have had some practical ideas but who had very few. I have heard a man say that a 180-deg. bend in a steam pipe was no better for expansion than a straight piece of pipe with elbows. He could not see why the fire in a high-pressure boiler could not be banked over night and the steam be allowed to flow into the heating system without seriously lowering the water level in the boiler in a period of eight hours. He also could not understand why a building with a large window area exposed to the full force of the wind in the New England climate, could not have the heat shut off all night without anything freezing because in a much more southerly location this practice prevailed in a building of several more stories and which was sheltered by other buildings near-by.

We can well ask the question: Who is the "know-it-all" in this case? Surely not the engineer who needs the patience of Job to listen to such statements and yet if the positions were reversed, how long would the engineer expect to remain if he made such statements?

Then there are many employers who have the honesty to say that they do not know anything about the mechanical end of the business and tell their engineer that he must go ahead and do as he thinks best and that it is up to him not to prove a failure.

In conclusion, we can be sure that no engineer who does not try to give his employer the full value for money received can expect that the employer is going to have the same feeling toward him that he would have if he fully trusted him. When once there is a feeling of suspicion on the employer's part it is time for the engineer to depart for other fields before he is invited to do so.

G. H. KIMBALL.

East Dedham, Mass.

How the Pump Valve Deck was Cracked

In answer to Mr. McGinness' inquiry, I would say the crack was caused by internal stresses in the division wall. The walls of the casting being very thick, 1½ to 2 in., the cracked part looks to be of very small cross-section compared to the thickness of the walls of the casting. When the casting was cooling in the mold the sides and ends would naturally cool first, radiating heat in every direction, leaving the division wall to cool last. This being the case, and as cast iron shrinks on cooling from a red heat, the internal wall would be subject to tension causing the internal stress mentioned. In service, no doubt, the temperature of the air surrounding the pump was higher than the water forced through the valves, this would also increase the stresses on the division wall and on the top valve deck. This fracture is not due to an increase of the discharge pressure for the gaskets in the pump and line would give way before the wall would fracture.

ELLSWORTH TONKIN.

Columbus, Ohio.

INQUIRIES OF GENERAL INTEREST

Whistling Sound in Boiler

When a boiler occasionally makes a whistling sound as the firedoor is opened or the damper closed slightly, what causes it, and can any harm result?

W. C.

This sound is probably the noise made by the air passing through the firedoor crevices. Beyond admitting more air than is necessary for complete combustion, thus reducing economy, no harm is done.

Relative Efficiency of Return Tubular and Locomotive Boilers

Which is the more efficient, the return-tubular or the locomotive boiler?

C. W.

The return-tubular boider is generally more efficient when properly designed, well set and having good draft. It also has better furnace combustion and less loss of heat by radiation and generally in the chimney as well.

Automatic Stop Governor

What is the function of an automatic stop governor?

E. D.

The automatic stop attachment on a throttling governor usually is an idler pulley resting on the governor belt, the supporting arm of the pulley being connected to the governor so as to automatically shut off the steam if the governor belt breaks or comes off. On Corliss engines various contrivances are used to accomplish the same or the equivalent function of such an attachment. The most common of these is the safety knock-off cam.

Working Strength of Joint

What would be the allowable pressure in a boiler 60 in. in diameter with a shell $^1/_2$ in. thick having a joint efficiency of 68 per cent. and constructed of metal having a working strength of 9000 lb. per sq.in.?

R. E. R.

The working strength of the joint per inch of length of shell would be

$$9000 \times \tfrac{1}{2} \times 0.68 = 3060 \text{ lb.},$$

therefore, in a longitudinal joint the allowable boiler pressure would be

$$\frac{2 \times 3060}{60} = 102 \text{ lb per sq in.}$$

Heating Surface in Pipe Coil

How is the heating surface estimated of a wall coil of four 1-in. steam pipes as used in factory heating systems?

J. K.

Base the heating surface upon the superficial pipe area, neglecting the small increase of heating surface due to fittings. The outside diameter of 1-in. steam pipe is 1.315, and the external circumference 4.131 in.; therefore a 1-ft. length has

$$\frac{4.131 \times 12}{144} = 0.344 \text{ sq ft}$$

In a four-pipe coil each foot-length of coil has

$$4 \times 0.344 = 1.376 \text{ sq ft.}$$

of heating surface

Lift of a Safety Valve

What is the lift of a safety valve?

N. B.

It is the distance which the valve rises vertically above its seat.

Finding a Chimney's Least Diameter

What should be the least internal diameter of a chimney 81 ft. high, if 2.88 lb. of coal are burned per horsepower per hour and the horsepower is 160?

E. R. R.

According to Kent's formula, where allowance is made for burning 5 lb. of coal per horsepower per hour,

$$Hp = 3.33 \times E \sqrt{H}$$

where

Hp = Horsepower

E = Effective cross-sectional area of the chimney in feet.

H = Height in feet.

In burning 2.88 lb. per horsepower per hour the formula is adapted to the conditions by dividing by 5 and multiplying by 2.88, whereupon, with the substitutions indicated, it becomes

$$160 = \frac{2.88}{5} \times 3.33 \times E \sqrt{81}$$

By transposing and solving,

$$E = 9.268 \text{ sq.ft.}$$

which equals the area of a circle the diameter of which is 3.44 ft., or about 3 ft. $5^1/_4$ in. For round chimneys the actual diameter should be 4 in. greater to allow for friction, or 3 ft. $9^1/_4$ in.

Determining Equivalent Evaporation

In making a test on a boiler having 105-lb. pressure, with feed water at 305 deg., how is the evaporation at 212 deg. worked out?

G. J.

The equivalent evaporation from and at 212 deg. F. and atmospheric pressure is the actual evaporation multiplied by the factor of evaporation. The latter is determined by dividing the total number of heat units received per pound of water by the heat units required to convert one pound of water at 212 deg. into steam at atmospheric pressure; i.e., by the latent heat of evaporation which, from and at 212 deg. F. and atmospheric pressure, has been determined to be 970.4 B.t.u. This is based on a heat unit being considered as $^1/_{180}$ of the heat required to raise a pound of water from 32 to 212 deg. F. The formula is

$$\frac{H - h}{970.4} = \text{Factor of evaporation}$$

where H is the total heat above 32 deg. in the steam and h the total heat above 32 deg. in the feedwater, both found from steam tables. In this case the steam pressure was 105 gage, which equals

$$105 + 15 = 120 \text{ lb. absolute.}$$

According to the Marks and Davis steam tables, to raise 1 lb. of water from 32 deg. F. to 120 lb. absolute pressure would require 1189.5 heat units, which is H in the formula. The feedwater temperature being 305 deg. F., h would equal

$$305 - 32 = 273 \text{ deg. above 32 deg.}$$

To be more exact h may be taken from the steam tables, corresponding to 305 deg., where it is found to be 274.7 B.t.u.

The factor of evaporation then is

$$\frac{H - h}{970.4} = \frac{1189.5 - 274.7}{970.4} = \frac{914.8}{970.4} = 0.9427$$

Leakage of Furnace into Front Smoke Connection

In firing a 66-in. by 16-ft. flush-ended return-tubular boiler with natural gas the boiler front gets very hot and it is sometimes difficult to generate enough steam. When coal was used as fuel there was sufficient draft and no difficulty in making all the steam that was required. What is the cause and remedy for the trouble?

G. W. P.

The difficulties are probably due to the passage of burning gases direct from the furnace to the front uptake through cavities in the front furnace wall, or to imperfect sealing-off of the furnace from the front connection at the front end of the boiler.

Relation of Ammonia Compressor Cranks

On a double-acting horizontal ammonia compressor, how should the cranks be set to get the best results in steam consumption and steady speed?

J. H. S.

The crank for the steam cylinder of a compressor should be set at 90 deg. with the compressor-cylinder crank. The compressor will not run smoothly if the flywheel is too light. For a given weight of flywheel, there will be a steadier motion if the steam-cylinder and compressor-cylinder cranks are set at 90 deg. to each other than when placed at 180 deg.

ENGINEERS' STUDY COURSE

Logarithms—Part 1

We have learned in recent lessons how to extract the square and cube root. We have learned, too, that the product of several powers of the same quantity is that quantity raised to the power indicated by the sum of all the exponents. Thus

$$8^2 \times 8^3 = 8^5$$

because

$$8^2 = 8 \times 8$$

and

$$8^3 = 8 \times 8 \times 8$$

and

$$8^2 \times 8^3 = 8 \times 8 \times 8 \times 8 \times 8 = 8^5$$

You can raise a quantity to any power by multiplying it by itself the indicated number of times, thus

$$8^7 = 8 \times 8 \times 8 \times 8 \times 8 \times 8 \times 8 = 2,097,152$$

You can get any root of a quantity by taking the square root as many times as 2 will go into the index of the required root. Thus to get an 8th root, as

$$\sqrt[8]{4434}$$

you extract the square root

$$8 \div 2 = 4 \text{ times}$$

When the index is an odd number subtract 3 from it, divide the remainder by 2, extract the square root that number of times and then take the cube root. Thus to get the seventh root.

$$7 - 3 = 4; \quad 4 \div 2 = 2$$

so we take the square root twice and then the cube root, and the sum of all these indices or exponents will be

$$2 + 2 + 3 = 7$$

All this would involve much figuring, but fortunately it is not necessary. The use of logarithms enables one to perform operations involving roots and powers with great simplicity.

In the following table a series of numbers in geometrical progression, 1 — 2 — 4 — 8, etc. (see lesson Dec. 17) is made to correspond with a series of numbers in arithmetical progression 0 — 1 — 2 — 3, etc.

Number	Logarithm
1	0
2	1
4	2
8	3
16	4
32	5
64	6
128	7
256	8
512	9
1,024	10
2,048	11
4,096	12
8,192	13
16,384	14

The numbers in arithmetical progression are the logarithms of the corresponding numbers in geometrical progression "to a base of 2."

The sum of the logarithms of any numbers is the logarithm of the product of those numbers. For example,

The *log.* of 4 = 2
The *log.* of 64 = 6

The *log.* of 256 = 8

Adding the logarithms of 4 and 64 together we obtain 8, the number corresponding to which is 256, which is the product of 4 and 64.

Again,

The *log.* of 2 = 1
The *log.* of 16 = 4
The *log.* of 512 = 9

The *log.* of 16,384 = 14

This same thing would apply to multiplying a number by itself, thus:

The *log.* of 8 = 3
8 = 3
8 = 3

The *log.* of 512 = 9

To multiply three 8's together, i.e., to raise 8 to the third power or "cube" it, we might add three of its logarithms together, which would give 9, which is the logarithm of 512, the cube of 8, for

$$8 \times 8 \times 8 = 512$$

But a simpler way would be to multiply the *log.* of 8 by 3

log. 8 = 3
exponent = 3

log. 8^3 = 9 = *log.* 512

Hence: To raise a number to any power multiply its logarithm by the exponent of the given power. The product will be the logarithm of the power required.

Division by Logarithms

To multiply two numbers together we added their logarithms. Division is the opposite of multiplication, so we can divide by subtracting logarithms.

Subtract the logarithm of the divisor from the logarithm of the dividend. The remainder will be the logarithm of the quotient.

Example: Divide 16,384 by 512.

log. 16,384 = 14 = (*log.* dividend)
log. 512 = 9 = (*log.* divisor)

log. 32 = 5 = (*log.* quotient)

To raise a number to a given power we multiplied the logarithm by the exponent of that power, obtaining the logarithm of the power as a product.

Getting a root is the opposite process to finding a power and may be done by the opposite process of division.

To find the root of a given number, divide the logarithm of the given number by the index of the root. (2 for the square root, 3 for the cube root, etc.) The quotient will be the logarithm of the required root.

Example: What is the cube root of 4096?

$$\textit{log.}\ 4096 = 12$$
$$\text{index} = 3$$
$$\frac{12}{3} = 4 = \textit{log.}\ \text{of the cube root}$$

The number corresponding to the logarithm 4 is 16, which is the cube root of 4096. (See if it is not.)

$$16 \times 16 \times 16 = 4096$$

What is the value of $64^{\frac{3}{2}}$

As has been explained in a previous lesson (Dec. 24) this means that 64 is to be raised to the third power and then the square root extracted. It is, therefore, the square root of the cube of 64. But $\frac{3}{2} = 1.5$, and the expression can equally well be written $64^{1.5}$. This says

raise 64 to the 1.5th power. This would be complicated by ordinary arithmetic, but see how easily it is done by logarithms:

$$\begin{array}{l} \textit{log.}\ 64 = 6 \\ \text{exponent} = 1.5 \\ \hline \textit{log. of } 64^{1.5} = 9 = 512 \end{array}$$

Let us see if this is right. It was to be the square root of the cube of 64. Then the cube of 64 must be

$$512 \times 512 = 262{,}144$$

and it is because

$$64 \times 64 \times 64 = 262{,}144$$

You have probably noticed before this that this is an incomplete table even as far as it goes. There is no logarithm given for 3. It would be somewhere between 1 and 2. Likewise the logarithms for the numbers between 8 and 16, in a table made like this one to a base of 2, would lie somewhere between 3 and 4.

The tables of logarithms in ordinary use, called "common logarithms" are made to a base of 10 as follows:

No.	log.
1	0
10	1
100	2
1,000	3
10,000	4
100,000	5

The logarithm of 1 is 0 in any system. In this system the logarithm of 10 is 1. The logarithms of the numbers from 1 to 10 lie between 0 and 1, as follows:

No.		log.
1	=	0.0000000
2	=	0.3010300
3	=	0.4771213
4	=	0.6020600
etc.		

The logarithms for the numbers between 10 and 100 lie between 1 and 2 and consist of 1 plus a decimal fraction, as, for example:

No.	log.
10	1.0000000
23	1.3617278
92	1.9637878

The logarithms for the numbers between 100 and 1000 are between 2 and 3 and consist of 2 plus a decimal fraction, as, for example:

No.
100 = 2.0000000
279 = 2.4456042
672 = 2.8723693

The logarithm is thus seen to consist of an integer and a decimal fraction. The integer is called the "characteristic" and is always one less than the number of integer places in the number. The decimal fraction is called the "mantissa.' Thus in the

$$\textit{log. of } 279 = 2.4456042$$

2 is the characteristic and .4456042 is the mantissa. The *log.* of a wholly decimal number is "negative," i.e., it is less than nothing. Remember that. Thus the characteristic of the *log.* of 0.018226 is $\bar{2}$. Notice the minus sign over a number indicates that it is negative.

The reader who cannot use logarithms is urged to study well each lesson so that he may be prepared for succeeding lessons that are to appear. In the next lesson we will learn how to use logarithmic tables, i.e., learn how to find the *logs.* of given numbers and given numbers when the *logs.* are known.

Practice Questions

(1) What is the chief purpose of logarithms?

(2) What is the base of the system of common *logs.*?

(3) To what numbers do the following characteristics relate: 0, 1.; 2.; 3.; 4.?

(4) Give the rules for the use of logarithms in performing examples in the following: (a) multiplication; (b) division; (c) raising a number to a given power; (d) finding the root of a given number.

Answers to Last Week's Problems

(1) 211.

(2) (a) 0.9283; (b) 1.357; (c) 5.9721.

(3) 85,184.

(4) 13.88 in.

(5) $\dfrac{92 \times 20}{200} = 9.2$. $\sqrt[3]{9.2} = 2.095$ in., say 2 in.

Study Course Exchange

The following are additional names of those desirous of exchanging lesson papers with others who are following the Course:

John E. Ketchem, Simsburg, Conn.; George H. Reed, N. S. Indian School, Santa Fé, N. M.; D. A. Dickinson, 441 South Piere St., Lima, Ohio.

Fire Brick Melting Points

The United States Bureau of Standards has defined the melting point of firebrick as being the lowest temperature at which a small piece of brick can be seen distinctly to flow. The following melting points of important materials in firebrick were determined:

Kaolin, 1740 deg. C.; pure Al_2O_3, 2010 deg.; pure SiO_2, 1750 deg.; bauxite, 1820 deg.; bauxite clay, 1795 deg.; chromite, 2180 deg. Silicon carbide begins to decompose at 2220 deg. after prolonged heating, but does not melt at much higher temperatures with short heating. Forty-one samples of fireclay brick were tested, the melting points of which were from 1555 to 1725 deg. C.; eight samples of bauxite brick had melting points from 1565 to 1785 deg.; three of silica brick from 1700 to 1705 deg.; one chrome brick gave 2050 deg. and one magnesia brick gave 2165 deg.

Recording Analyzers for Power Plants

By F. D. Harger

Whenever an average American power plant is visited one cannot help but wonder why it is that so little is done regarding the economical control of boilers and furnaces.

Most steam users have been content to leave the problem of stoking entirely in the hands of the firemen, who handled the furnaces guided only by their "experience."

Even the best fireman cannot tell the steam pressure carried without a pressure gage. He cannot judge the correct draft pressure, thickness of the firebed, or whether he is feeding coal properly, by looking at his fire, any more accurately. In many ways we are far behind the times as regards fuel economy and furnace control.

The burning of fuel in a furnace is purely a chemical action and a remedy for existing conditions has been found and is widely adopted in Europe, namely, the continuous and automatic analysis of the products of combustion.

It is not necessary to have a laboratory in the boiler house or employ an expert chemist to see what one is doing. There are instruments on the market, which in

every way are accurate and reliable, are far beyond the experimental stage and are suitable for use in the most exposed positions in boiler plants. On several occasions I have used CO_2, and CO recorders and have found them capable of obtaining accurate results under the most trying conditions.

Much has been said about CO_2 recorders and many may have wondered whether they are of any practical value. They are as indispensable to the working of a boiler as the steam-engine indicator is to the proper operation of an engine.

Combustion of fuel involves a chemical union between the fuel and atmospheric oxygen with the subsequent release of heat and the formation of carbonic acid gas, CO_2, which is the ultimate product. It is evident that the percentage of CO_2 present in the exit gases must serve as the only important and reliable guide to the control of a furnace. The presence and percentage of this CO_2 can only be determined by chemical analysis. The table shows the loss of fuel in relation to the percentage of CO_2 in the exit gases.

Percentage of CO_2	16	15	14	13	12	11	10	9	8	7	6	5	4	3
Loss in fuel, %	10	12	13	14	15	16	18	20	23	26	30	35	45	60

From this it follows, that if a low percentage of CO_2 is discovered in the exit gases, considerable heat is being lost which should be transmitted to the water in the boiler tubes and a high percentage of this gas would indicate that most of the heat generated has been developed by the combustion of any given amount of fuel.

For makers of producer gas, water gas, etc., it is obvious that the knowledge of the percentage of CO is very important, although a continuous record of CO is not absolutely necessary in common boiler house practice. An occasional test is generally sufficient. A CO recorder stands in the same relationship to a producer plant that a CO_2 recorder does to a boiler furnace. In both cases the percentage of gas analyzed should be as high as possible. Blast-furnace gases, coke-oven gases, etc., are in the same category and improved efficiency may be confidently expected from plants where analyzing instruments are installed.

To the thinking man it will be apparent that the installation of an effective instrument for fuel or gas control is a paying investment.

Pittsburgh Smoke Abatement League

The Smoke and Dust Abatement League, in Pittsburgh, was organized Dec. 9 at a meeting of about 40 representatives of local civic organizations. It was decided to hold an exhibition at which the evil done by smoke will be shown, as well as the modern and approved methods which have been made available for its prevention.

W. T. Todd was elected president and appointed the following plan and scope committee, which will suggest persons to fill the other offices and make arrangements for the proposed exhibition: W. E. Snyder, mechanical engineer; Dr. A. A. Hamerschlag, of the City Planning Commission; Dr. R. C. Denner, of the University of Pittsburgh; O. P. Hood, chief mechanical engineer of the United States Bureau of Mines, and Miss H. M. Dermitt, secretary of the Civic Club of Allegheny County.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Brother Stephenson, of Elko, Nev., quoting from the "American Machinist," notes that "the Berliner Werkzeugmaschinenfabrik A. G. vom L. Leutner, Berlin, Germany, has built a planer 49 ft. long." We were beginning to feel grateful for this nugget of information when we met up with this trifling persiflage: "It would have to be that long to carry the name-plate." You get old Steve, don't you?

Just when many cities have tacked up "No Smoking" signs and hired smoke inspectors to seek whom they may devour in plants and factories, along comes an artist of European renown (whatever that is) who says: "Smoke and dirt tone down the building outlines and give them a soft, artistic color that is pleasing." Now, what do you know about that? Remember when your dad used to tone down your outlines when he caught you smoking behind the barn? Don't put any stress on this artistic bunk; watch your chimbley, and let science triumph over art for once.

White marble is "bad for gravestones," says the U. S. Geological Survey press bulletin. We are indebted to the bulletin for many little shop kinks, but in touchin' on gravestones, it makes a grave mistake. We are, we hope, a long way from being tucked beneath the daisies, so why should this pessimistic investigator upset our mental equilibrium by intruding this dread information upon us? To our mind, it's just the other way: gravestones are bad for us! The cutest little marble affair that ever emerged from the quarry could not tempt us personally to use it. There are times when a press censorship would be welcome.

R. O. Richards, up to Framingham, Mass., writes us that he believes in practicing economy in the plant, but when the chief insists on a man opening the window before looking out, to save wear on the glass, economy gets on one's nerves. Sounds like a pancless joke?

Mebbe you never knew Billy Blivins, over to Boston? You know the type, anyway. Billy could lean up against the rail with ten other fellows, take ten "comforters," and go home in a fair state of ebriety. Billy never "came across" himself. One day, however, hopes (don't omit the "e," linotyper) ran high when he apparently thawed under the internal heat he was generating. He rammed his hand into his loose-change pocket, threw out his thirty-four chest, put one foot on the rail, and chirped: "Well, boys, what are we goin' to have—rain, or snow?"

"Choosing a misfit vocation and lacking mechanical intuition make most mechanics dissatisfied," says a writer in the "American Machinist." You're right, son. We once knew an undertaker who was too jolly to take his vocation seriously, and an engineer who should have been a housewrecker.

A German scientist has double-crossed Doc. Osler by contending that a man is at his best at 50. Osler said 40; that at 60 he (the workman) was useless. Why, you and I know men who were worse than useless at 25, and they lived up to it all their lives. On the other hand, "Leslie's Weekly" recently published thumbnail portraits of eight Pennsylvania engineers who were over 90, and one was 95! Any one of them looks fit to leap into his cab, pull her wide open and refuse to slow down if he saw old man Osler on the track just ahead of the engine.

A stream of some three hundred million dollars flowed into Charity reservoir during 1912. Well, it's one of the best built reservoirs within our ken, and has had no very bad leaks or breaks. There may come times when we will wish that the "riparian rights" had been granted to more deserving consumers, but doubtless this stream will flow out again much less rapidly, screened of the fungi of greed and distilled of its impurities.

Whoops and bangs rose loudly above all the other noises in the plant, and everybody looked toward the outside door. Horan, the chief, sent Doran out to find the reason. "All right, chief," said Doran on his return from the yard; "it's only Kelly. He's breaking his New Year's resolutions!"

Sometimes, in his eagerness to impress his prospective employer, the applicant overdoes it. Jimmy Bates did. He wanted a job firing and tackled the chief. "I'm strong, willing and able to do a big day's work." The chief said nothing. "Why," said Jimmy, "I can do as much as my old man and my brother together. You know them, chief, they're firin' for you now." "You can, eh?" snapped the chief; "come to work in the morning. I'll fire the old man and your brother. You can take their places."

New York Engineers' Entertainment and Reception

The combined associations of the National Association of Stationary Engineers, of Manhattan and the Bronx, held a large open meeting and entertainment on Friday, Dec. 27, in the Engineering Societies Building, New York City, where a reception was tendered to National President John F. McGrath; National Vice-president James R. Coe; National Secretary Fred W. Raven; National Treasurer Sam B. Force; National Trustees Reynolds, Kerley and Brownhill, Past National President Edward F. Kearney, and other national officers. This is the first time in the history of the national association that so many of the national officers were entertained under one roof, coming as they did from all parts of the country.

"The Grand March" of the N. A. S. E. New York City Engineers

The addresses of the officials were on the welfare of the association, and were well received by a large and enthusiastic audience. The entertainment provided during the evening was furnished by Herbert Self, Joe McKenna, Billy Murray and Jack Armour.

On Dec. 28, at Terrace Garden, the associations held what was undoubtedly the largest and most successful ball ever given under N. A. S. E. auspices. The decorations were unusually artistic. Fourteen past national presidents attended and at the close a supper was given the grand officers.

The general committee was composed of Robert Johnson, chairman; Lorenzo S. Everson, vice-chairman; William M. Logan, treasurer; Frederick Felderman, secretary, and 40 members from the 10 combined associations. Seven numbers on the entertainment program were furnished by professional favorites from the vaudeville stage and were much enjoyed.

NEW PUBLICATIONS

MODERN ORGANIZATION. By Charles DeLano Hine. The Engineering Magazine Co., New York City, N. Y. 110 pages; 5x7½ in.; not indexed. Price, $2.

This book is the latest addition to the Works Management Library. The matter originally appeared in "The Engineering Magazine," from January to July, 1912.

As Major Hine's work has been on the Harriman Lines, the application of his doctrine has been to railroad activities. Although very little detail of application and results are given, the use of the system apparently involves but slight physical change in the organization. It rather reaches its results through a policy of mental suggestion, accompanied by means for establishing and fostering individual responsibility.

The book is divided into eight chapters: The Unit System on the Harriman Lines; Operation of the Unit System; Broadening of the Ideals of Line Supervision; Over-specialization; Fallacies of Accounting; Supplies and Purchases; Line and Staff; Genesis and Revelation of Organization.

The necessity of training subordinates is emphasized by the statement that "The best experts are those who can impart a working knowledge to the layman."

One aim of the system is to free executives from detail, so that under the changed conditions "more energy is now expended in seeing that instructions already issued are carried out." An important feature is the recognition of the desirability of promoting personal relations throughout the entire organization.

COAL: ITS COMPOSITION, ANALYSIS, UTILIZATION AND VALUATION. By E. E. Somermeier. McGraw-Hill Book Co., New York City. Cloth; 175 pages; 6½x9½ in.; 8 illustrations. Price, $2.

To acquaint especially the mechanical and power-plant engineer, the chemist and the non-technically trained man and operator with the purchase and selling of coal is the purpose of this book.

It begins by treating the subject of the constituents of coal and the calculation of the heat value by proximate analysis. The paragraph in Chapter I on "Moisture" is instructive and very practical. Chapter III, on "Sampling" should be read by all who purchase coal on the heat value basis. Relative to securing a representative sample the author says: "Too much emphasis cannot be laid on the importance of care and thoroughness in taking and handling the sample on which the chemical results are to be obtained." Again, ". . . as much or more time or money may be expended in securing a sample as is expended in having it analyzed."

Methods of coal analysis are then taken up and followed by directions for the determination of the calorific value of fuel. The next chapter discusses the possibilities of getting rid of the sulphur pyrite in flake or lump form by washing the coal.

The chapter on the "Purchase of Coal under Specification" contains interesting abstracts of the specifications of some large cities as quoted from the "Municipal Journal." The author advises paying premiums or bonuses on coals that are better than specifications call for and also believes that a penalty should be imposed on a seller if the coal is below the specified grade.

The book is concluded by a chapter on flue-gas analysis and a number of analytical tables of many kinds of coal.

This book should prove especially useful to power-plant men.

MECHANICAL EQUIPMENT OF FEDERAL BUILDINGS. By Nelson S. Thompson. Second revised edition. Williams & Wilkins Co., Baltimore, Md. Cloth; 6x9 in.; 272 pages. Price, $2.

The purpose of this book, written by the chief mechanical and electrical engineer, Office of the Supervising Architect, Treasury Department, is to set forth the basic data used in designing the mechanical equipment for all buildings under the control of the Treasury Department.

As this book goes so thoroughly into the specifications, costs, tests, requirements and merits of the various kinds of mechanical equipment for federal buildings, the most the reviewer can do is to enumerate the classification of such equipment, which is as follows: Heating and ventilation; plumbing, drainage and water supply; gas piping; conduits and wiring systems, including telephone and watchman and time-clock system; lighting; elevators; small power plants; motors and controlling apparatus; vacuum cleaning systems and operating data. The appendix, which comprises 72 pages, contains two papers, one on "Commercial Practice" in regard to factory heating and forced hot water circulation systems, by H. C. Russell, and the other on "Heating by Forced Circulation of Hot Water from a Central Station," by Leon A. Warren.

The last chapter of the appendix on "Suggestions to Superintendents" is of great value, not only to superintendents of federal buildings under erection, but to those in charge of the installation of the mechanical equipment in any building, particularly an office building.

One thing noticeable about this book is the practical manner in which all of the many branches of equipment are treated. They are dealt with just as a practical, strictly business-like consulting engineer should carry on his work—simply and thoroughly.

While the book is most valuable to those connected with the office of the Supervising Architect of the Treasury Department, all contracting and consulting engineers as well as architects will find it useful. The book also abounds in helpful information for operating engineers of office building plants.

West Penn Electric Banquet

Covers were laid for 56 persons at the fourth annual banquet of the West Penn Electric Co., held in the New Zimmerman House, Greenburg, Penn., Dec. 11, 1912. The regular monthly meeting was held in the hotel parlors at 11 a.m., previous to the banquet. W. R. Kenney, superintendent of lighting, presided over the first period, later turning the meeting over to District Superintendent William Snite, when papers were read by E. I. Barnard on "Electric Motors vs. Gas Engines," and L. T. Jackman on "Meter Reading and District Work."

The dining-room decorations bore out the holiday spirit, and a concealed orchestra furnished excellent music for the banqueters.

With Mr. Kenney as toastmaster, responses were made among others by E. D. Dreyfus, statistician; H. P. Chambers, superintendent of lighting; T. S. Henderson, manager of the new business department, of the Pittsburgh office; F. A. Moesta, district superintendent at Kittanning, and W. S. Anderson, chief clerk of the Connellsville office.

Seventh Annual Banquet of the Southern Power Co.

The seventh annual banquet of the Southern Power Co. and allied interests was recently held in the auditorium, Charlotte, N. C., about 500 guests being present, including Dr. W. Gill Wylie, vice-president, and R. B. Arrington, secretary-treasurer, from New York, the local officers and those resident at Spartanburg, Greenville, Anderson and other points in South Carolina.

Vice-president W. S. Lee acted as toastmaster. After the banquet he happily introduced each speaker, and urged that all present consider themselvs members of one big family. Telegrams of congratulations were read from J. B. Duke, president of the Southern Power Co.; B. N. Duke, vice-president; J. M. Bradshield, and John Frazier, Hobart, Tasmania. Mr. Frazier recently went from the local offices to Tasmania to construct a large hydro-electric plant for the British government.

Dr. Wylie, the first president and founder of the Southern Power Co., as the principal speaker, delivered an interesting address reminiscent of his early interest in the development of water power on the Catawba River and of the early days of the Southern Power Co.

Following Dr. Wylie's address the lights were turned out, and on a screen at the rear of the auditorium was shown one of the company's power plants on the Catawba River. The electric lights gleamed through the windows of the structure on a storm-ridden night, forked and zigzag lightning flashed through make-believe clouds in a startlingly realistic manner and torrential rain descended. The climax of the scene was the wrecking of a transformer.

A parody on "Alexander's Rag Time Band" by a double quartet was one of the decided hits on the program. The singers, equipped as a lineman's crew, paraphrased the ragtime melody into the vocal declaration that the Southern Power Co. was the grandest in the land.

PERSONALS

R. Bowen, for some time past the general sales manager of the Epping-Carpenter Co., Pittsburgh, Penn., has been promoted to the position of general manager of that company.

C. E. Harrison has resigned as chief engineer of the Bell Telephone Co., Pittsburgh, Penn., to enter the consulting field. His work will include power-plant design, erection, testing and supervision. His address will be 3821 California Ave.

Frank R. Brosius, for the past ten years supervising engineer for the Columbus Ry. & Light Co., resigned on Jan. 1, to assume a similar position with A. B. Leach & Co., of New York, at Cincinnati, as supervising engineer of the power stations of the Cincinnati and Covington traction interests of that company. Mr. Brosius is a graduate of the State School for Soldiers' and Sailors' Orphans, at Xenia. He has been active in the organization of the local branch of the National Association of Stationary Engineers, and at its last meeting that organization adopted resolutions expressing their esteem for him and their regret that he is now to withdraw from the local organization. Mr. Brosius won the second prize offered by Power, Dec. 26, 1911, for the best practical article on "Running a Turbine."

Capt. Charles H. Manning, for more than thirty years superintendent of the mechanical and engineering departments of the Amoskeag Manufacturing Co., has resigned because of ill health. Capt. Manning is recognized among engineers as a high authority on steam, and the plants of the Amoskeag company testify to his engineering skill. He has been associated with such engineers as Haswell, Isherwood, Kafer, Loring, Melville and Thurston, and is known to steam engineers throughout the country. Capt. Manning was born in Baltimore, Md., June 9, 1844. His early education was received in Baltimore and Cambridge, Mass., and in 1860 he entered the Lawrence Scientific School of Harvard University to study civil engineering.

In 1861 he returned to Baltimore, and became an apprentice in the Reeder marine-engine works. In 1863 he was appointed third assistant engineer of the navy, where his knowledge and comprehensive grasp of scientific matters brought him to the attention of Chief Engineer Isherwood, who assigned him to the making of experiments on superheating steam on the "Adelaide" and other vessels. In 1870, Capt. Manning became an instructor at the Naval Academy and helped organize a course of instructions for cadet engineers, which is one of his most valuable achievements. He was a member of the first advisory board in 1881, which prescribed the first general characteristics of the warships of what was termed the new navy, and was the only engineer to vote for steel vessels. After 12 years of continuous duty he became mechanical engineer of the Amoskeag Manufacturing Co. During the Spanish-American war he was stationed at Key West as chief engineer of repairs. Capt. Manning had charge of all the Amoskeag company power plants, and was the architect and builder of the recently completed Coolidge mill. The steam units there installed have 65,700 nominal boiler horsepower, all of Capt. Manning's design. In 1885 Capt. Manning designed and installed a 2000-hp. horizontal water turbine, the first large installation of its kind. He also designed a 30-ft. flywheel, with a face of 108¾ in. and a thickness of 12 in. This rim was made up of 40 rings of ash. Capt. Manning has been consulting engineer for several other large mills. He is a past vice-president of the American Society of Mechanical Engineers, a member of the Army and Navy Club of New York, American Society of Naval Engineers, United States Naval Institute, American Society of Naval Architects and Marine Engineers, American Association for the Advancement of Science and the American Society of Cotton Manufacturing.

POWER

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Two Ways of Giving Instructions

A GRUFF "CALL DOWN" ACCOMPLISHES LESS THAN AN EXPLANATION.

Difficulties of a Mechanical Engineer

By G. H. Leaverton

SYNOPSIS—After being engaged to prepare plans for needed improvement the superintendent is found to be hostile and the president looks on. Uneconomical conditions were finally eliminated under the direction of a new superintendent.

That the value of a power plant decreases and the operating and maintenance charges increase very rapidly through the lack of coöperation of the several heads of departments of a concern, is well known to mechanical, consulting and operating engineers.

The mechanical engineer, by virtue of his technical training and general experience, is capable of intelligently outlining and inaugurating economical methods and installing the proper equipment. As an illustration of the fallacy of placing technical power-plant matters in the hands of nontechnically experienced men, as well as the lack of coöperation between the different departments, an experience of the writer is given herewith.

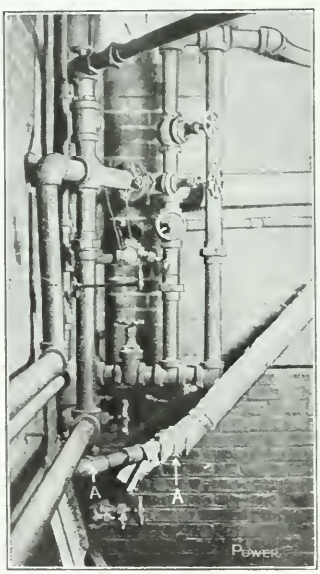


Fig. 1. Piping Where Elbow Wore Rapidly

Hostile Superintendent

Shortly after entering the employ of a certain concern as mechanical engineer, I was instructed by the president to prepare a report on one of their several power plants which he thought could be greatly improved and more economically operated.

Plans were prepared and approved by the vice-president, and upon his recommendation the president ordered the superintendent to proceed with the alterations and new installations. The superintendent after looking them over went to the president, who hardly knew a condenser from a feed-water heater, and proceeded to find fault with all of the contemplated alterations. The superintendent would not coöperate with the engineering office and the president would not make him, so the improvements were held up until the superintendent resigned, and his successor, a man with technical training, saw the need of such improvements and proceeded to install them in accordance with the plans already prepared.

Heating the Feed Water

The plant consisted of two 500-hp. condensing engines, one of which was in continuous operation, and 700 hp. in boilers. There were three boiler-feed pumps, two being piped to small individual tanks, which acted as open feed-water heaters.

The feed pumps, vacuum pumps and other auxiliaries exhausted into these tanks, thereby heating the feed water. The pumps were on a level with the tanks, and frequently got steam bound, which necessitated cooling the water before it could be handled. Then, to further heat it after leaving the feed pumps, it was pumped through a home-made closed heater.

The large engines were steam jacketed and the steam was originally trapped, but the station engineer had bypassed the trap and run the jacketing steam to the closed heater, thence to a storm-water sewer, without a trap in the line. Several drip lines from the main steam header were also run to this heater without being trapped. As the steam had an unrestricted passage through the jackets and the heater to the sewer, vapor was caused to arise from various sewer inlets. To prevent this evil a jet condenser arrangement was constructed to condense the steam.

Pipe *A*, Fig. 1, shows the line conducting the jacket steam to the heater. Owing to the high velocity attained, the 45-deg. elbow kept continually cutting through and had to be renewed.

New Heater

The new arrangement provided for a standard make of open feed-water heater of ample proportions, placed above the feed pumps at a sufficient height to insure a constant head of water, thereby preventing them from getting steam bound. All of the high-pressure drips, jacket steam and the like, all trapped, were discharged into the new heater. There was also a dynamo engine, operating at night only, which had been exhausting to the atmosphere; this exhaust was also taken to the heater.

In Fig. 2 are shown the tanks at the feed pumps and in Fig. 3 the numerous pipe lines in the station. Steam or water pipe was duplicated two or three times to no purpose whatever. If the engineer wanted to shut off any particular line or unit he had to follow it along its numerous and devious repetitions to find which valves to operate. The slovenly and careless method of running piping, shown so clearly in Fig. 3, is only an average sample of the care that this whole station received. All of this was done away with and a simple and systematic layout of both steam and water piping was put in.

Blowing Down Boilers

Another great source of waste was in the method of blowing down the boilers. It was the custom to blow down six times in 24 hr. A simple calculation, based on the amount blown down each time and using a lower heat rating of the coal than was actually obtained, showed that it took approximately 500 tons of coal per year to heat this water blown out. This could easily have been cut down to 200 tons per year, as upon inquiry among other firms using identically the same feed water it was only necessary to blow down twice in 24 hours.

This was objected to by the superintendent, who claimed that the boilers would scale badly, in spite of all the proofs offered to the contrary from other reliable firms operating under similar conditions.

The water normally is not a scaling water, yet they were using a compound at the rate of 1 lb. per 10,000 gal. when ½ lb. was ample. The boilers had a single tee-cock in the blowoff line. This I considered positively dangerous to both the boiler and the employees. I have seen the fireman take a 2-ft. lever handle and open these cocks as quickly as possible, little realizing the enormous water-hammer on the piping that was produced. I often wonder why an elbow or other part did not give way. The superintendent again objected to any change here as a needless expense, claiming that they never had any accidents and he "guessed" they never would.

The total cost of all the alterations and improvements did not exceed $2500, and the station could have saved this amount in reduced expense in about one year.

The other two plants of the concern were in far better condition than the one in question, and showed the character and ability of their respective engineers, who were not only willing, but anxious to have the improvements made, and they coöperated with the engineering office as far as was possible.

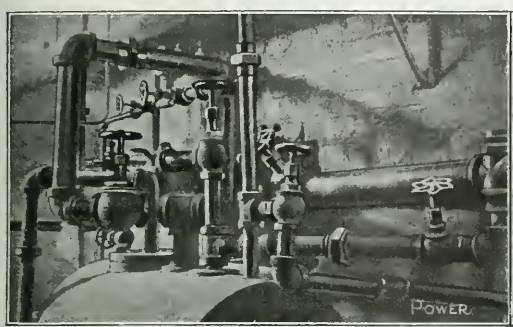


Fig. 2. Piping above Tank

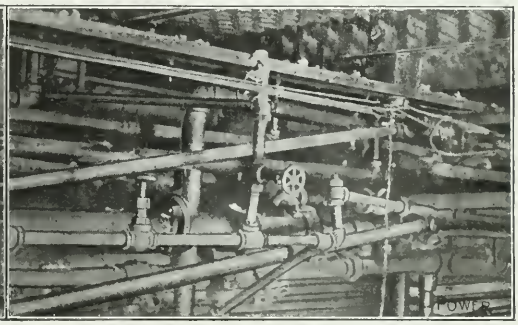


Fig. 3. A Tangle of Piping

"Keeping Tab" in Industrial Plants*

By P. Lundeby

SYNOPSIS—Some suggestions as to the best manner of recording facts and data concerning power-plant operation which should prove valuable to those desiring to establish a system of record keeping.

In operating engineering the former goodly amount of guesswork, as to results obtained, is giving way to reliable data arrived at by a thorough system of "keeping tab" on every phase of operation.

The chief engineer, being given the responsibility and power to act, should gather, from the first day he assumes charge, accurate information about all machinery and apparatus under his charge and file it for future use. He should aim at definite and accurate data for two purposes; one to determine without delay matters pertaining to the maintenance, operation and efficiency of any machine when required, the other to determine the cost per unit of steam, electricity, air, water, etc.

The first will include all principal dimensions of the boilers, chimney, engines, generators, pumps and all working machinery, also the sizes and style of all packing. Valves, correctly set, should be trammeled, and the correct clearance at both ends of cylinders recorded.

On installing new machinery, the results of the initial trials should be recorded, and filed for reference. Duplicate copies of these results should also be made. It is of value to know the conditions under which a boiler, engine, pump or other apparatus worked when new, for comparison with later tests and trials. The engineer can also increase the efficiency of the men and thereby the plant, in establishing a system of daily records kept by the men in charge of the various departments, dealing with every important factor relating to the equipment they are handling.

These data are essential as the very basis on which to arrive at the real results obtained. Equally important is the continuous record of the feed-water temperature. An inserted thermometer in the feed line will make this easy. An intelligent chief fireman, given the necessary devices, will usually interest himself in securing all this information, as it adds to the feeling of responsibility and perhaps dignity. He should record at in-

*Read before the second annual meeting of the Institute of Operating Engineers, New York City, Sept. 6 and 7, 1912.

tervals, the temperature of the flue gases as well as readings of the draft gage, the time each boiler has been in operation, when cleaned and inspected, and any defects, leaks, etc., discovered. The periodical visit of the boiler inspector should be welcomed and of interest and benefit as well to the chief fireman as to the chief engineer, and his advice considered by both.

The watch engineer should fill out a form, giving all necessary information about the conditions under which the machinery under his care is working. Here is where recording instruments are valuable. Knowing that there will be a curve to tell the tale, will tend to keeping all the equipment well cared for. Recording instruments are especially valuable where operation is continuous day and night. Where a number of different departments use water, steam and electricity for manufacturing generally metering the consumption of each department will pay.

The "keeping tab" must be progressive. Beginning in the boiler room, detailed information should be gathered from the various departments, to which the output of the power plant is being distributed.

To the cost per boiler horsepower-hour must be added the cost of operation of the boiler room, materials, repairs and maintenance, the proportional amount of administration expenses and interest, as well as a fair percentage of depreciation of buildings and equipment. By intelligent use of the indicator, the consumption of steam of the various engines and generators will be arrived at, and fairly accurate constants determined to simplify the daily calculation of the amount of steam used per unit of the output as kilowatt-hours, tons of refrigeration and cubic feet of air and water per brake horsepower-hour. To these items must be added the correct proportion of the several expense burdens.

Record keeping will be made easier by using printed blanks for all purposes, all aiming at the finished result at the end of the month, when a resumé of the daily log, in concise form, should be submitted to the manager's office. There is a daily education in "keeping tab," the value of which has rarely been appreciated by employer or operator. The latter will find that the more means and devices he equips the plant with for this purpose, the more he realizes how little he really knew before, and how throwing light on one subject will usually lead to the discovery of another hitherto unnoticed source of waste.

All the monthly record sheets should be filed from month to month and year to year for comparison. In plants where many electric motors are used, readings should be taken at intervals, or when undue sparking and heating occurs, to see that they do not carry depredatory overloads. A water meter furnishes an excellent check on the proper working of a pump, its capacity when installed being known. To check the meter on the feed-water line some means should be provided. If the pumps get the water from a tank, the volume being known, readings of the meter and fall of the water level in the tank may be taken simultaneously for comparison. If inaccuracy exists the amount it represents should be added or deducted from the daily meter readings.

To determine the efficiency of condensing plants and cooling towers, temperatures should be taken of water entering and leaving the towers, preferably by providing the pipes with inserted thermometers. Often an undue amount of waste is taking place here, and considerable economy may be obtained by proper investigation and experiments. Where scale-forming water is used, piping must not be allowed to scale too heavily, as this will soon reduce the capacity and increase the friction head on the pumps. Another item often unheeded is the wasted exhaust-steam from the pumps, small engines, traps, etc., which might be profitably used in heating feed water. Record keeping reveals all these losses. The top of the smoke-stack, while not a CO_2 recorder, affords a persistent indicator of the management of the fires.

In large industrial plants having a machine shop for making repairs and changes, a technical assistant, as draftsman, if added to the force, should be entrusted with the keeping of the operation records and the supervision of all recording or indicating devices. Plants of this kind covering large areas often have a network of underground piping, an accurate plan of which is essential. It should be kept uptodate by drawing in new lines and eliminating old ones, new prints being made when any marked alterations have taken place. This will save much trouble and labor.

It is worth the expense to make a graphic chart, dividing the year into quarters, these into months and these again into days, showing a continuous curve of fuel consumption, evaporation of water and output of products. It tells an interesting story at the end of the year. These may be traced and prints made for the engineers and manager's office.

A wide-awake engineer, knowing every detail about his plant, seeing its weaknesses and possibilities, and daily studying and learning new facts and features of its various branches will prove himself to the manager, as the best consulting engineer he could employ.

⁂

River Water Used Eight Times

Power can be developed upon many surface streams and applied to the recovery of the water of the streams after it has sunk into the earth in the lower valley lands.

An instance of this character, according to the United States Geological Survey, is to be found along Santa Ana River in southern California. A part of the water is stored in a reservoir in the San Bernardino Mountains and the flow of the stream is thereby regulated. After it escapes from the reservoir it is diverted through a power plant and electric power is generated. Below this power plant it is rediverted and passed through a second power plant. Below this it is all distributed and used by cities or for irrigation about Redlands and Highlands.

The waters that return from the irrigation are recovered in springs and flowing wells and by pumping plants, a part of the power developed higher up on the stream being used for the pumping. This recovered water is used for irrigation about San Bernardino and Riverside. A part of it reappears in the river above Riverside Narrows, where it is again taken out into a power ditch whose waters are returned to the river above Corona. A few miles below it is picked up by canals and distributed to the orange and deciduous groves about Anaheim and Santa Ana. The part of it that returns there, by irrigation, to the ground water is once more recovered by the pumping plants and flowing wells west of Santa Ana.

A single drop of water in its progress from the mountains to the sea, a distance of only 100 miles, may thus be used as many as eight times.

Size, Capacity and Power Required for Centrifugal Fans

By Frank B. Gilbert, Jr.

SYNOPSIS—By the use of diagrams and without calculation the size of fan required to handle a given volume of air per minute against a given pressure may be determined, and the power required to drive it found. The charts also give the capacity when other factors are known.

The accompanying diagrams are intended as a convenient means for obtaining graphically the relations between friction to be overcome in air ducts, size and speed of centrifugal-fan wheels, and the horsepower required to drive them.

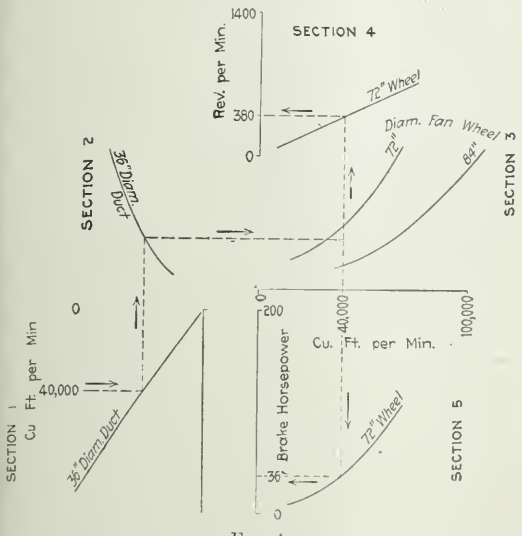


FIG. 1

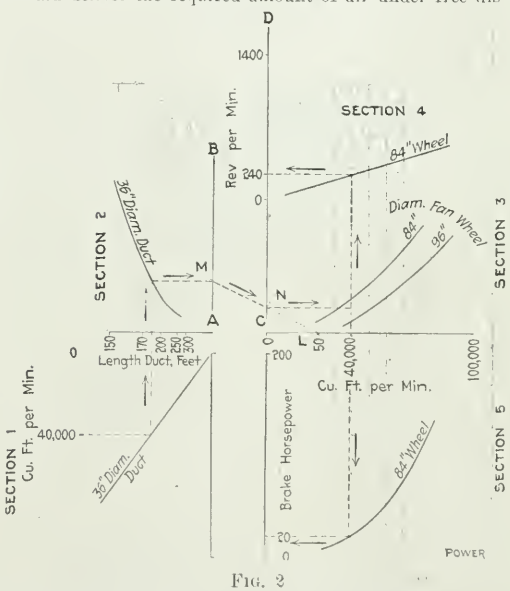


FIG. 2

In some instances the diagrams may not entirely replace mathematical calculations to determine a fan which is to meet specified requirements, but even then are advantageous to check the calculations.

The results obtained from the diagrams are applicable only to the average type of fan now on the market and will vary slightly with differences in various manufacturers' constructive details.

The friction losses used in plotting the diagrams compare favorably with actual tests made by the author on long circular iron ducts.

The following example illustrates the use of the diagrams:

To transmit 40,000 cu.ft. of air per minute through a duct 36 in. in diameter and 100 ft. long, what size, speed and horsepower of fan are necessary?

For clearness the problem is shown in Fig. 1, isolated from the large diagram.

In the diagram for steel-plate fans in Section 1 is found a scale of fan capacities and curves for different diameters of ducts. Beginning at the 40,000 division of the capacity scale a line is traced horizontally to the right until it intersects the curve for 36-in diameter duct. From this point a path is followed upward to the 36-in. diameter duct curve in Section 2 and thence horizontally into Section 3, stopping directly over the 40,000 mark of the scale showing cubic feet of air per minute in this section.

The position thus reached is found to be between curves for fan wheels 72 and 84 in. in diameter. The 84-in. fan would deliver the required amount of air under free discharge but would not maintain enough pressure to overcome friction of the specified duct. A 72-in. fan would deliver a slight excess of pressure.

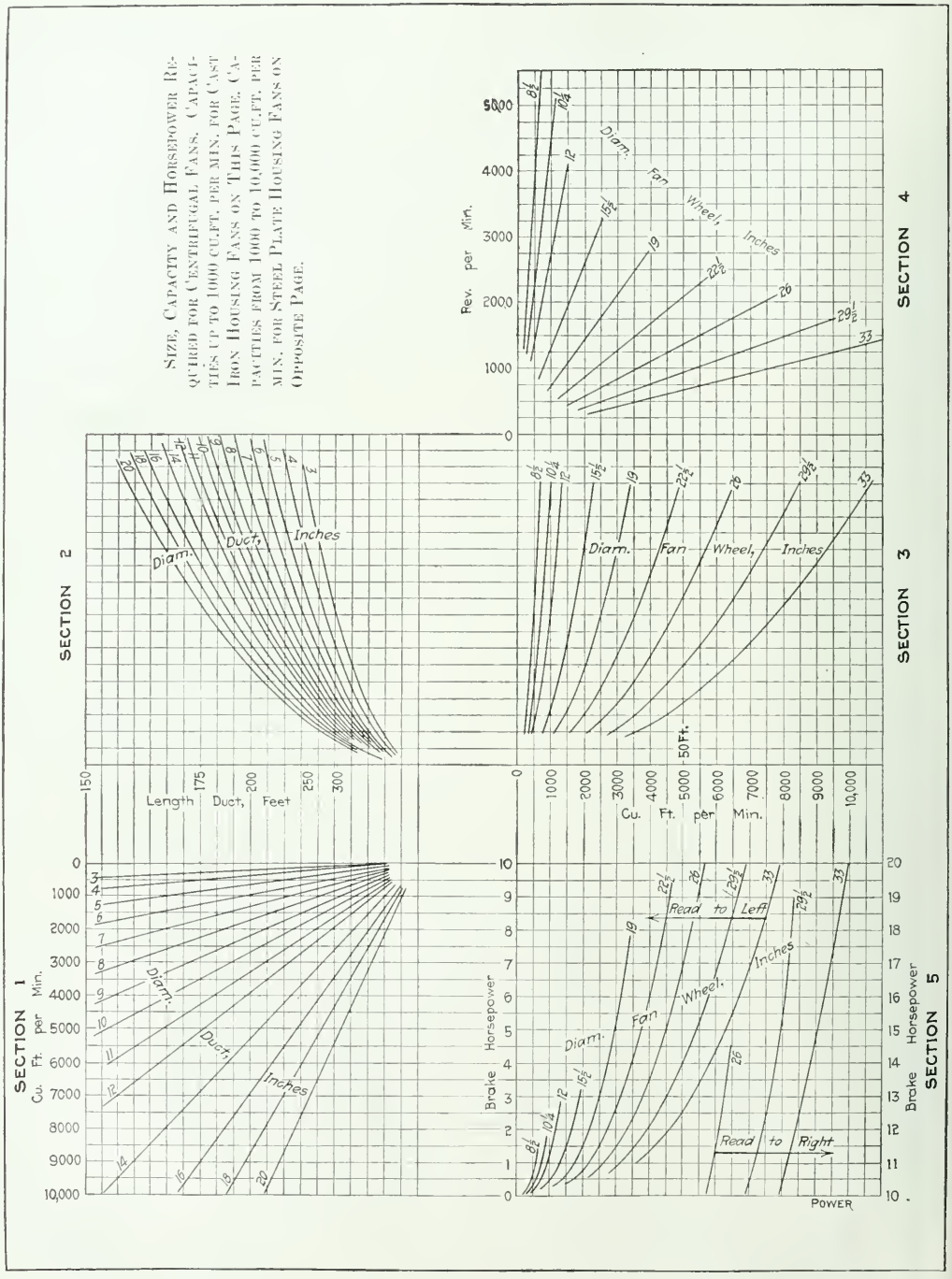
Selecting, then, a 72-in. fan and tracing vertically upward from the 40,000 cu.ft. per min. graduation into Section 4, another 72-in. fan wheel curve is intersected at a point opposite the speed of 380 r.p.m.

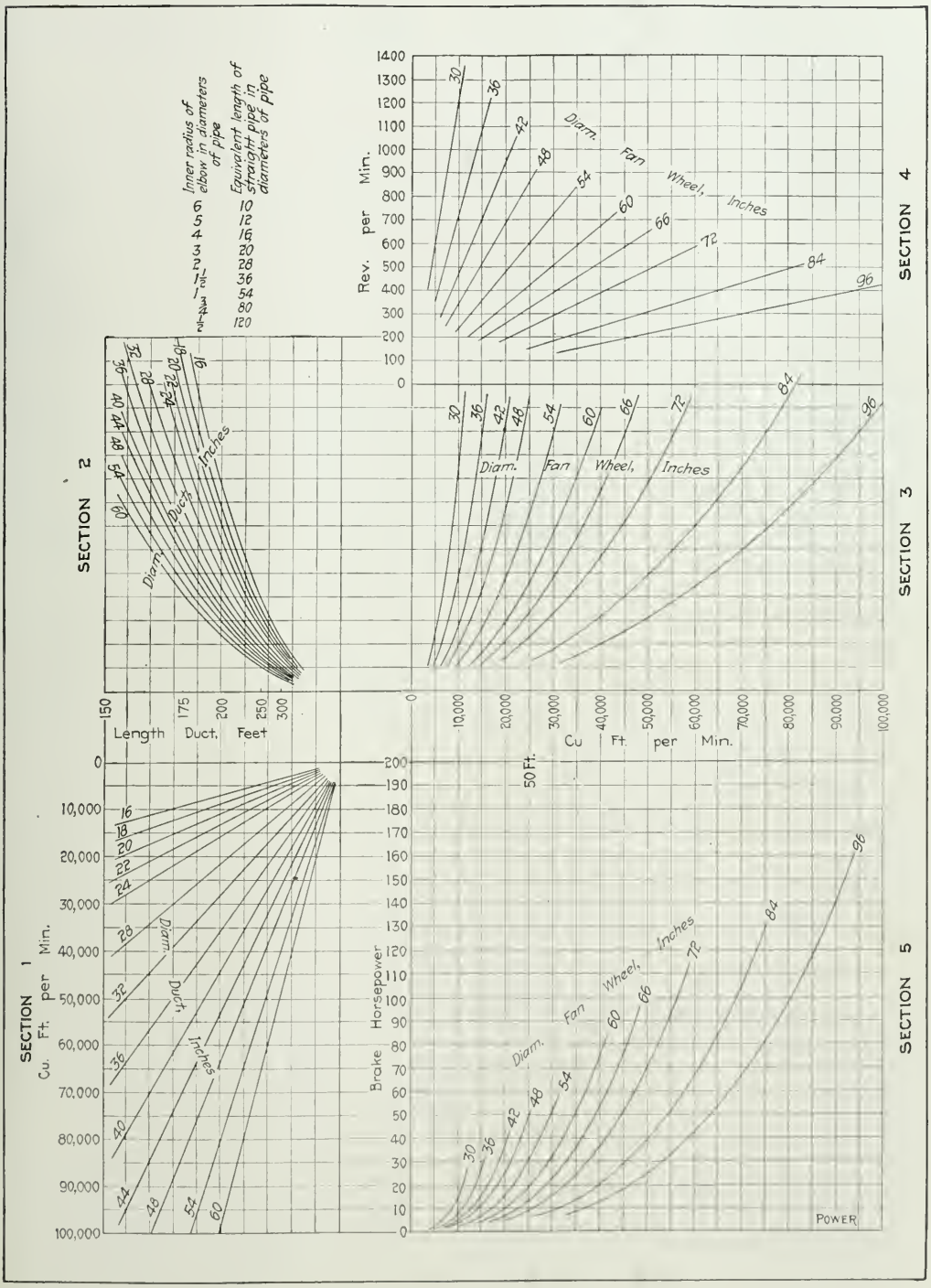
Returning to the vertical line passing through the 40,000 mark and following downward into Section 5 until the 72-in. fan curve is met, and then to the left, 36 hp. is found to be required to operate the fan.

In the solution of the above problem no use was made of the scale in Section 2, entitled "Length of Duct," the 50-ft. division of which appears in Section 3. This is because the diagrams are based on friction losses for ducts 100 ft. long and with this length, as in the problem just solved, no account is made of duct length.

If the duct had been 50 ft. long the problem would have been solved, as shown in Fig. 2, which is identical

SIZE, CAPACITY AND HORSEPOWER REQUIRED FOR CENTRIFUGAL FANS. CAPACITIES UP TO 1000 CU.FT. PER MIN. FOR CAST IRON HOUSING FANS ON THIS PAGE. CAPACITIES FROM 1000 TO 10,000 CU.FT. PER MIN. FOR STEEL PLATE HOUSING FANS ON OPPOSITE PAGE.




SECTION 1
Cu. Ft. per Min.
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
16
18
20
22
24
28
32
36
40
44
48
54
60
Diam.
Duct
Inches
SECTION 2
Length Duct, Feet
150
175
200
250
300
Inner radius of elbow in diameters of pipe
6
5
4
3
2½
2
1½
1¼
1
¾
½
Equivalent length of straight pipe in diameters of pipe
10
12
16
20
28
36
54
80
120
SECTION 3
Cu Ft. per Min.
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
30
36
42
48
54
60
66
72
84
96
Diam.
Fan
Wheel,
Inches
SECTION 4
Rev. per Min.
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
30
36
42
48
54
60
66
72
84
96
Diam.
Fan
Wheel,
Inches
SECTION 5
Brake Horsepower
50 Ft.
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
30
36
42
48
54
60
66
72
84
96
Diam.
Fan
Wheel,
Inches
POWER

with the solution in Fig. 1 except that upon reaching line *AB* at *M* (Fig. 2) instead of continuing horizontally to line *CD*, a straight-edge is placed to coincide with points *M* and *L*, thereby determining point *N* in line *CD*. Continuing horizontally from point *N* as was done in Fig. 1, an 84-in. fan running at 240 r.p.m. and requiring 20 hp. is obtained.

Corrections should be made for friction losses, due to elbows in the air duct, according to the table of equivalent lengths of straight pipe on page 75.

Development in Marine Condensers

SYNOPSIS—Main factors controlling heat exchange, the steam and water paths and some typical condenser data and performances.

Before the Institute of Engineers and Shipbuilders, in Scotland, William Weir read an extended paper on the "Development in Auxiliary Units between Exhaust Pipe and Boiler." The chain of auxiliary machinery involved in the treatment was: condenser, circulating pump, air pump, feed-heating apparatus, feed-pumping apparatus and feed makeup apparatus. As a preliminary the main principles of the respective apparatus were recorded and the approximate dates annexed in each case. The apparatus listed above was then discussed

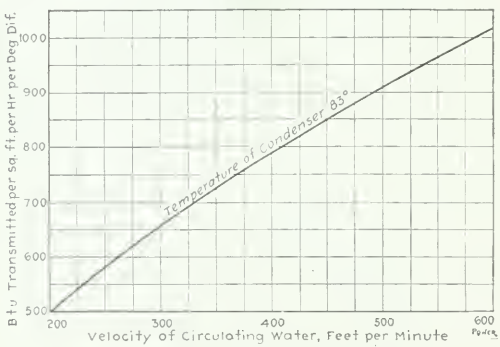


FIG. 1. TRANSMISSION RATE DIAGRAM

at some length under distinctive heads. The sections on pumps were of exceptional interest, but in the present review only that part of the paper relating to the condenser proper will be considered.

Viewed broadly, a surface condenser is an apparatus wherein a heat exchange takes places between exhaust steam and water. The main factors controlling this exchange are: The temperature difference between the steam and the water; velocity of steam; velocity of water; presence of noncondensable gases in the steam, and to a lesser extent, the mean temperature of the steam and water.

The conditions to which a well designed condenser for marine use and for any specific vacuum and sea temperature should conform are: Minimum weight and space, minimum power absorbed by circulating pump, minimum cooling of condensed water, minimum variation of pressure on the steam side.

In a condenser in which the water passes through a number of small tubes inside a containing vessel to which the steam is introduced, the steam path must be such that the maximum velocity is attainable with the

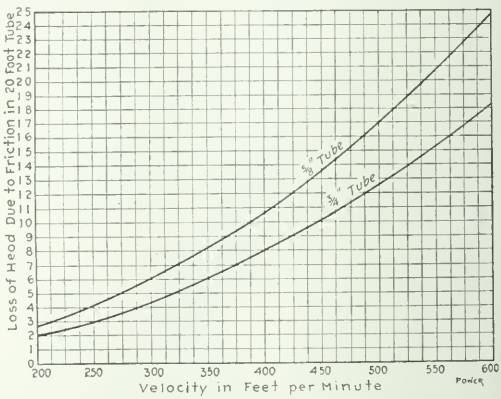


FIG. 2. FRICTIONAL HEAD DIAGRAM

minimum loss of head. Obviously then the path must be, as nearly as possible, straight, and the velocity must be maintained constant in value. The first condition precludes the use of baffle-plates, the second necessitates a varying cross-sectional area, which should vary in proportion to the condensation. The only other factor directly influencing the contour of the steam path is the quantity of noncondensable gases present. Maximum efficiency requires that this quantity should be kept at a minimum. This constitutes the function of the air pump. It is to be noted that the steam path has been considered without reference to its condition—condensed or noncondensed. Where one pump is used both as

TABLE 2. CONDENSER WEIGHTS.

Class of Installation	Vacuum in inches	Sea Temperature, Deg. F.	Material of Shell	Type of Condenser	Weight per hp. in lb.	Engines	Assumed Steam consumption per hp. in lb.
Cargo Steamer 3000 hp.	23	85	Cast Iron	Old Rectangular on engines	8.3	Reciprocating	15
Cargo Steamer 3000 hp.	23	85	Steel	Circular	7.5	Reciprocating	15
Cargo Steamer 3000 hp.	25	85	Steel	"Uniflux"	3.35	Reciprocating	15
Cross-Channel Boat	28.5	55	Steel	"Uniflux"	3.5	Turbine	14
Atlantic Liner	28.5	60	Steel	"Uniflux"	4.07	Turbine	14
Destroyer (1909)	26.5	55	Sheet Brass	Oval	2.7	Turbine	16
Destroyer (1912)	28	55	Steel	"Uniflux"	2.1	Turbine	14
Cruiser (1907)	27	55	Cast G.M.	Circular	4.4	Turbine	15
Cruiser (1912)	28.25	55	Steel	"Uniflux"	3.4	Turbine	14
Battleship (1906)	28.5	55	Cast G.M.	Circular	6.06	Turbine	14½
Battleship (1912)	28.5	55	Steel	"Uniflux"	4.09	Turbine	13½
Distilling Condensers	18	80	Steel	"Uniflux"	2.2	Turbine	15

TABLE 1. TYPICAL "UNIFLUX" CONDENSER DATA AND PERFORMANCES

Installation No.	Class of Installation.	Type of Engine	Horsepower.	Steam Consumption lb. per hr.	Cooling Surface, sq.ft.	Condensation rate in lb. per sq.ft.	Guarant. Vacuum 30-in. Bar	Sea Temperature Deg. F.	Actual Vacuum 30-in. Bar	Sea Temperature Deg. F.	Circulating Water Outlet	Hot-well Temperature Deg. F.	Diff. Deg. F. from theoretical Outlet Temp.	Diff. Deg. F. from theoretical Hot-well Temp.	Tubes Diameter Thickness Length	No. of Flows	Type of Air Pump
1	Small Mail Steamer	Reciprocating	5,800	87,000	3,282	26.5	25.5	55	20.8	41	110	110	0	0	¾" 18" W.G. 7' 8¾" overall	3	Engine-driven Edwards
2	Mediterranean Mail Steamer	Reciprocating	12,000	180,000	8,000	22.5	26	60	27.7	72	99	104	6	1	¾" 18" W.G. 7' 6" overall	3	"
3	English Channel Steamer	Turbine	12,000	180,000	8,636	20.8	28.5	55	28.95	49	69	69	9.5	9.5	¾" 18" W.G. 10' overall	2	Independent "Dual"
4	Intermediate Atlantic Liner	Reciprocating	12,000	174,000	8,440	20.6	27	60	27.2	53	103	98	9	14	1" 18" W.G. 10' overall	2	"
5	Fast Cruiser	Turbine	22,000	340,000	16,820	20.25	28.25	55	28.8	54	75	78	8	5	¾" 18" W.G. 7' 6" overall	2	"
6	Battleship	Turbine	27,000	418,500	21,600	19.375	28.5	55	28.85	57	76	76	5	5	¾" 18" W.G. 8' overall	2	"
7	Destroyer	Turbine	17,000	240,000	9,000	26.7	28	55	28.55	45	78	78	11	11	¾" 18" W.G. 15' overall	1	"
8	A London Power Station	Turbine	2,000 K.W	28,800	3,000	9.6	28	75	28.1	75	95	95	3	3	1" 18" W.G. 6' 2½" overall	4	"
9	Large Cargo Steamer	Reciprocating	5,300	80,000	4,400	18	25	85	27.3 26.75	44 84	105 106	111 106	6 11	0 11	¾" 18" W.G. 7' 6" overall	3	Engine-driven "Dual"
10	Fast Yacht	Turbine	2,500	46,000	1,300	35.1	27	55	27.3	54	86	101	10	9	¾" 18" W.G. 7' 6" overall	2	Independent "Dual"
11	Turbo-Generator Condenser	.....	.....	15,000	300	50	.....	.....	23¾	60	111	120	.....	.....	1" 18" W.G. 5' overall	4	"Monotype"

air pump and condensed-water pump, the path of the steam will necessarily be identical with that of the condensed water. Where separate pumps are used, however, it will be possible to treat the vapor and water differently, and to give them different paths. Whether it will be advisable to do so or not will depend on whether the transmission rate is affected by the state—liquid or gaseous—of the material on the steam side of the tubes, always remembering that equal velocities are assumed.

Practical considerations which limit the closeness of pitch of tubes, prevent the attainment of high velocities with water except when held in suspension in a gaseous medium, so that in a condenser of homogeneous construction, sumberged tubes are not compatible with the highest overall efficiency.

FIG. 3. REPRESENTATIVE TUBE-PLATE DIAGRAMS

As there is no change in volume of the water, and as its heat-transferring value, per unit temperature difference, is not appreciably changed during its course, its velocity, and hence the cross-sectional area of its path, should be uniform. The velocity chosen will depend on the mode of variation of the heat-transmission rate with velocity and on the permissible expenditure in obtaining that velocity. In considering the correct quantity of circulating water to use, it must be borne in mind that the quantity of water chosen will necessarily define its outlet temperature. The actual quantity will then be a matter of compromise between expenditure of pumping it, and its reaction on the length of water path required before the outlet temperature which it entails is attained.

The variation of heat-transmission rate with velocity of water flow is shown in Fig. 1, and the variation of

frictional head with velocity (for the size of tube commonly used) is shown in Fig. 2. In Fig. 1 it must not be assumed that the rates indicated are in every sense absolute. Under certain favorable conditions much higher rates have been attained. Reference to Table 1 will show a number of examples typical of modern practice for widely varying conditions, together with the performance of these installations.

One of the most interesting installations is No. 8, where economy in circulating water was necessary, and No. 9 is also exceptional as showing the performance of one of the installations with engine-driven "Dual" air pumps. No. 10 shows the overload performance on a turbine yacht where light weight of condensing plant was of great importance. In the case of the reciprocating-engine installations the vacua being carried are too high for economical running, but in every example the trials were made to show high degrees of vacua as being of interest in connection with the condenser performances apart from the main machinery.

No. 11 gives the results of a turbo-generator condenser. It may be noticed that the condensation rate is more than twice the average rate for the other installations. The cooling surface is only 300 sq.ft., and 15,000 lb. is condensed per hour.

Fig. 3 shows three typical tube-plate diagrams showing how uniform velocity is attained by contour of the shell and varying pitch of the tubes to suit special conditions of space.

Table 2 gives some interesting figures regarding the weight of condensers. Adhering to principles of design previously given, results in a type of condenser wherein no attempt whatever is made in achieve what has been termed sectional or compartmental drainage. In condensers possessing this feature, it is stated that the water of condensation is intercepted and removed to the hotwell as soon as it is formed—the basic idea being that the heat-transmission rate will thereby be improved and the hotwell temperature increased for a given vacuum. So far as experiments carried out by my firm have shown, no influence on the transmission rate by the interception of this water can be traced, while the claim for higher hotwell temperature is no longer supported.

The carrying out of this drainage feature includes the subdivision of the condenser by baffle-plates or collectors lying approximately parallel to the steam path, the angle of deflection presumably representing the extent to which gravity is to assist in the interception and removal of the condensed steam. Now the velocity of steam flow in a high-vacuum condenser might be taken as 500 ft. per sec., which represents 340 miles per hour, and this explains the fallacy of sectional drainage together with the impossibility of its practical achievement.

Another misconception with reference to condenser design concerns the use of what might be termed an inverted condenser, i.e., one in which the steam admission is at the bottom and the air extraction at the top. It has been stated that in such a condenser the steam will not readily rise, but, as a matter of fact, the steam will rise with the velocity already indicated, and if space considerations permitted such condensers, their performance would be as good as that of existing installations.

New Theory of Condensation

SYNOPSIS—A thin film of air greatly reduces the heat transmission of a condenser tube. It is heavier than water vapor and to remove it most efficiently V-shaped passages are proposed.

In the discussion of Mr. Weir's paper before the Institution of Engineers and Shipbuilders in Scotland on marine condensers, air pumps and feed heating plants, an excerpt from which is published on the preceding pages, D. B. Morison, of Hartlepool, presented a new theory on surface condensation.

Mr. Morison started off by establishing initial uniformity of exhaust distribution over the tubes throughout their whole length, and while maintaining such uniformity over the entire condensing surface, he maintained at the same time a continuity of flow through a passage of decreasing area from the exhaust inlet to the air outlet.

To lengthen the path of vapor flow in his original small condenser, Mr. Morison cut a wedge into three pieces and set one above the other. This small condenser he presented to the Armstrong College and Professor Weighton's experiments with it definitely established the correctness of the principles, as may be seen by reference to his paper before the Institution of Naval Architects in 1906, which was generally conceded to be the most valuable report on "Surface Condensing Efficiency" ever published.

By subsequent experience with large condensers, Mr. Morison found that the conditions enabled the wedge shape to be maintained linearly by light guide plates, which not only cheapened the construction and lessened the weight of large condensers, but in condensers of any size facilitated the employment of wedges of the proportions which had been found by exhaustive tests to give the highest efficiency.

If no air were present in condensers, the problem of surface condensation would be simplified as no air pump would be required, but in practice the crucial problem in the attainment of high vacuum is how best to treat the small quantity of air which normally enters the condenser with the steam, and at the same time to make provision for dealing with the much larger quantities which result from accidental and inevitable leakage into the vacuum system. As the result of much investigation over many years Mr. Morison submitted the following theory whereby a solution might, he thought, be found along the simple lines of elementary first principles.

In 1905, J. A. Smith of Australia carried out some valuable experiments to determine the effect of air on heat transmission through a condenser tube. He found broadly as follows: That the presence of air in quantities that might have been deemed insignificant may, in fact, become the factor limiting the efficiency of a whole steam plant. For instance, air equal in pressure to only $\frac{1}{20}$ in. by the mercury gage, will at 90 deg. F. reduce thermal transmission some 25 per cent., while $\frac{3}{20}$ in. will lower it about one-half.

The experiment further demonstrated that in a con-

denser dealing with steam at 90 deg. smothered with air at a partial pressure of 0.3 in. it would be found that the cooling surface would have to be 2¼ times greater than if dealing with airless water vapor at the same temperature.

In the experiments the feature of interest is the extraordinary degrading effect which a film of air of minute thinness has on the heat transmission of a condenser tube. At the other extreme it is known that when air is present in large quantities in a condenser the lowermost tubes may become so air drowned as to be quite incapable of condensing any appreciable vapor. It is also established that air is heavier than water vapor and consequently the natural tendency of aerated vapor is to fall and not to rise. This is of course apart from all considerations of velocity of entry. Therefore the first essentials for condenser efficiency are that the weight of air which always remains in a condenser shall be reduced to a minimum and shall be so disposed as to cause the least possible resistance to the transmission of heat through the tubes to the circulating water flowing through them. Another essential is that the air particles shall not eddy by taking an erratic course in any given horizontal plane or by making multiple appearances in any plane. In other words each air particle shall take its shortest route from the exhaust inlet to the air outlet and not linger on the way.

Fig. 1

Fig. 2

Fig. 3

Such a theory at once suggests that exhaust steam should enter a condenser as a uniformly moving column, the sectional area of the column being the plan area of the top row of tubes. Continue this plan area unchanged and the condenser becomes a rectangular box. If hypothetical stability is assumed the condenser becomes filled with an infinite number of horizontal superposed films, the top film containing the least amount of air and the bottom film the greatest.

The air contained in such a condenser is the sum of the particles in all the films and as the function of an air pump is to minimize the weight of air which is normally present in a condenser, it is obvious that the lowermost film which is the film richest in air should be preferentially and wholly withdrawn by the air pump and be followed by the entire withdrawal of the superposed film and so on.

What would actually happen, however, in such a rectangular box under such conditions would be that the air pump would break through several films locally and by withdrawing a charge less rich in air and therefore inferior would leave the bulk of the lowermost and densest film undisturbed.

Now suppose by some means or other the lowermost film were disposed vertically instead of horizontally; the air pump would then draw no multiple layers from unstable thinness but one layer from stable depth. The nearest practical approach to this requirement is a wedge section having a very narrow outlet, as in Figs. 2 and 3.

Again suppose another hypothetical condition, viz.: that there is no air in the condenser Fig. 1, and that the condensate is withdrawn by a water pump. Assume also that the frictional resistance of the vapor passing over the tubes is *nil;* were such conditions possible in practice, the vacuum and the temperature throughout the condenser would be constant. Fig. 2 represents the same condenser under conditions of ordinary practice, viz.: with air and air pump. Assume the air to be as shown and that the air density is proportionate to the depth of shading. Suppose such a condenser to be working under conditions of vacuum stability and with no eddying anywhere. The shading would then be lightest at the top and darkest at the bottom, the temperature would be highest at the top and lowest at the bottom and the charge of air withdrawn by the air pump at each stroke would be the densest the condenser contains. Now suppose in Fig. 3 the conditions are identical with those in Fig. 2 in every respect except that in Fig. 3 a lighter shading is maintained at the bottom of the condenser, say, for example, one corresponding to the shade in the middle of Fig. 2. It should be remembered that the quantity of air admitted with the exhaust is precisely the same in both Figs. 2 and 3, but the weight of air which always remains in the condenser in Fig. 3 is less than that which remains in Fig. 2 by the amount below the center line in Fig. 2.

The general technical effect which is thereby produced is that every single tube in the condenser has been relieved of a definite amount of air insulation and is therefore able to transmit more heat to the condensing water with the result that the final temperature of the condensing water increases, the condenser cools and the vacuum rises.

It is the condenser which is primarily responsible for the high vacuum attainable under these conditions as by means of the wedge the air is arranged in density gradations which reach a maximum at the outlet from the condensing chamber, but the disposition of the gradations at the outlet must be such that a given weight of air presents as small a surface area and as great a depth as the practical requirements of sufficiency of passage will permit of. Concurrently the air pump is enabled to maintain such an air condition within the condenser that the air density at the air outlet is minimized, the air insulation within the condenser is reduced, and the greatest amount of heat is transmitted to the condensing water.

It should again be noted that each air pump normally withdraws exactly the same quantity of air per unit of time, viz.: the quantity which enters the condenser with the exhaust steam, but in Fig. 3 a less air density is maintained at the air outlet and therefore there is less air insulation within the condenser than in Fig. 2. The relation between a condenser and an air pump may thus be seen. For example, the ability of a condenser to create a very high vacuum may always remain latent if it is worked in conjunction with an inefficient air pump. What is required is such unit efficiency that combined will enable the very highest vacuum to be maintained which the condenser is capable of producing.

The next important consideration is the proportions of

the wedges. The thin end presents no difficulty whatever. It should be so narrow that the air forms a strip or plug of such stability that eddying or disturbance is impossible. In practice the width is usually determined by the diameter of one or more tubes with the necessary allowance for the passage of condensate.

The desideratum at the top of the wedge is to stop eddying. This can best be achieved by making the wedges as for example in Fig. 4.

It will be evident that the often misunderstood problem of intermediate collection of condensate and the consequent influence on its temperature now becomes very simple. Again refer to Figs. 1, 2 and 3. In Fig. 1 no air being present there is equality in temperature throughout the condenser, and on the formation of drops of condensate they splash over tubes in their descent and are

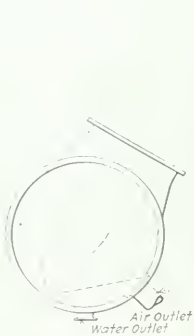


Fig. 4. Condenser with Multiple Wedge Chambers

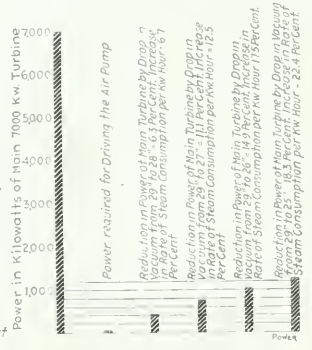

Power in Kilowatts of Main 7000 Kw. Turbine
7000
6000
5000
4000
3000
2000
1000
Power required for Driving the Air Pump
Reduction in Power at Main Turbine by Drop in Vacuum from 29 to 27 = 10.3 Per Cent. Increase in Rate of Steam Consumption per kw Hour = 6.7 Per Cent
Reduction in Power of Main Turbine by Drop in Vacuum from 29 to 27 = 10.1 Per Cent. Increase in Rate of Steam Consumption per kw Hour = 12.5 Per Cent
Reduction in Power of Main Turbine by Drop in Vacuum from 29 to 26 = 14.9 Per Cent. Increase in Rate of Steam Consumption per kw Hour = 15 Per Cent
Reduction in Power of Main Turbine by Drop in Vacuum from 29 to 25 = 18.5 Per Cent. Increase in Rate of Steam Consumption per kw Hour = 22.4 Per Cent.
Power

Fig. 5. Power Required by Air Pump and Effect of Drop in Vacuum

alternately cooled by the tubes and heated by the vapor until on arrival at the bottom they are approximately at the same temperature as that corresponding to the vacuum.

In Fig. 2, air being present, the temperature gradually decreases from the top to the bottom and therefore the drops of condensate when falling pass through a cold air zone with the result that the final temperature is less than that corresponding to the vacuum. The temperature of the condensate relatively to that of the vacuum therefore depends on the temperature of the air zone through which it falls, and also on the shape of the condenser.

Almost any condenser lends itself to the intermediate collection of condensate as some must fall on the sides and thus short circuit the colder air zones.

In Fig. 4 the multiple wedge chambers discharge into an air receiver which may or may not be fitted with tubes. For high vacuum tubes are very valuable as they enable the temperature of the air to be brought to within a few degrees of that of the condensing water. It will be noted that this effect is initiated in the base of the multiple wedges where many of the tubes are entirely sheltered from the streams of falling condensate and carried to its logical conclusion in the final air cooling chamber. Having obtained this high vacuum, what is its value? As will be seen by Fig. 5, in a commercial turbine plant it is represented by increased efficiency.

Dronsfield Pressure Controlling Valve

By the pressure of the air, or liquid passing through it, the action of this valve is automatically controlled. It will cut off or admit the flow at any predetermined pressure and prevent leakage of the operating fluid which would build up a back pressure behind the valve piston.

The valve body has a horizontal projection *A* with a central piston chamber, capped at the outer end, and holding a helical spring within a piston. The piston is beveled at one end and when in its outward position, with the spring compressed, seats against a stationary seat which also acts as a stop and cuts off the flow of fluid that may travel along the exterior of the piston. Normally the spring also presses the head of the piston against a valve seat at the opposite end of the piston.

In operation the fluid passes up through the pipe *B*, but is prevented from going further by the valve piston until some predetermined pressure has been reached which overcomes the pressure of the spring against the piston, and then the piston valve is moved away from its seat, which allows the fluid to pass through the valve. When this takes place the pressure is equal on both sides

Dronsfield Pressure Controlling Valve

of the piston. As soon as the pressure decreases on the inlet side of the valve, the spring will close the piston, thus preventing any flow of fluid through the valve at any pressure less than that determined as a minimum. The fluid is always admitted to the discharge side of the valve at, or above, the pressure at which the valve is operated.

The valve is useful in any system delivering a liquid, or fluid, under pressure, as, for example, one supplying oil burners for the generation of steam wherein the fuel oil is drawn from a supply pipe, atomized and discharged into a furnace by a jet of air or steam. In such a system the valve automatically closes when the liquid in the source of supply falls below the predetermined pressure and prevents any flow from the source of supply to the discharge until the predetermined or a greater pressure is exerted against the piston. When used with an atomizer the valve is connected to it by a nipple, as at *C*.

This device is manufactured by A. J. Dronsfield, 281 Admiral St., Providence, R. I.

ELECTRICAL DEPARTMENT

The Storage Battery—II

By John A. Randolph

The storage battery, as its name implies, is essentially an agent for the accumulation of electrical energy. There are various conditions which require the use of stored energy either from an economical standpoint or from actual necessity, and it is to meet the demands of these conditions that this type of battery is used. It is employed for various purposes, but its most important application is in connection with power stations as an accumulator of reserve power and it is in this field that it is found in its largest and most complete development. As thus used, its principal functions are: to aid in carrying the peak loads, to regulate the voltage on feeders and to act as a reserve source of power which can be drawn upon when the other sources fail.

There are various methods used in the connections of a stationary battery for charging and discharging, depending upon the size of the battery, the nature of the distribution system, the load factor and the economical requirements of the station. A common method of charging the smaller sizes used for oil switch control and other auxiliary work consists in the use of a motor-generator

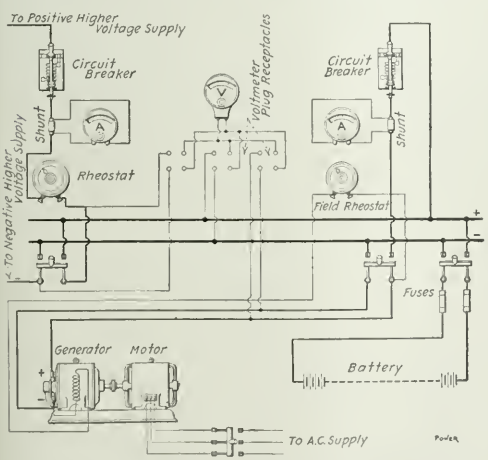


Fig. 1. Battery Arranged for Charging with either Motor-Generator Set or from Station Busbars

set of small capacity, the generator being connected across the battery busbars upon charging, and disconnected when the charge is finished. In another method, the charging current is taken from a set of station busbars carrying a higher voltage than the battery busbars, the current flow due to the higher voltage being regulated by a rheostat.

Fig. 1 shows a diagram of connections for a battery that can be charged by either of these two methods. The motor-generator set is driven by a motor whose current is furnished from the auxiliary supply mains of the station. In substations, an induction motor is generally used in order to have the charging set available at times when the direct-current station busbars are dead. The generator is connected through a switch and circuit breaker to the battery busbars. The supply leads from the station busbars are likewise connected to the battery

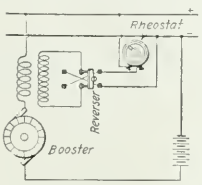


Fig. 2. Booster Connection on Two-wire System

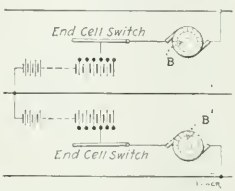


Fig. 3. Booster Connection on Three-wire System

busbars and a rheostat is connected in series with the positive side. By means of a voltmeter and plug receptacles connected as shown, the voltage of either charging source and of the battery can be ascertained at any time. The ammeters show the charging current of the respective sources and the flow is regulated by means of the rheostats. When a charge is completed, the circuit-breaker and main switch on the source used is disconnected, and the battery, which remains connected to its busbars, begins to discharge simultaneously. By this arrangement the continuity of service to the circuits fed from the battery busbars is not interrupted, the current being supplied during charge by the replenishing source.

With large batteries employed on the outside service of the station a different procedure is followed. These are generally used in conjunction with boosters upon both charging and discharging. The latter are low-voltage direct-current generators so connected that their pressure is added to that of the station busbars upon charging, and to the battery voltage during discharge. Were it not for the assistance of the booster, it would be impossible to send a charging current through the battery from the station busbars, after its voltage had been brought up to that of the latter. Moreover, it would be impossible to discharge the battery below this point.

Fig. 2 shows a fundamental diagram of one of the many methods used in connecting a battery and booster to a two-wire system. The booster is compound wound, the shunt field being capable of reversal through a pole-changing switch. By means of the latter, the booster voltage is added to that of the main busbars upon charge and is therefore opposed to the battery pressure, the result being that a current is caused to flow through the battery in the required direction, which is opposite to that of discharge. In discharging, the booster shunt field is

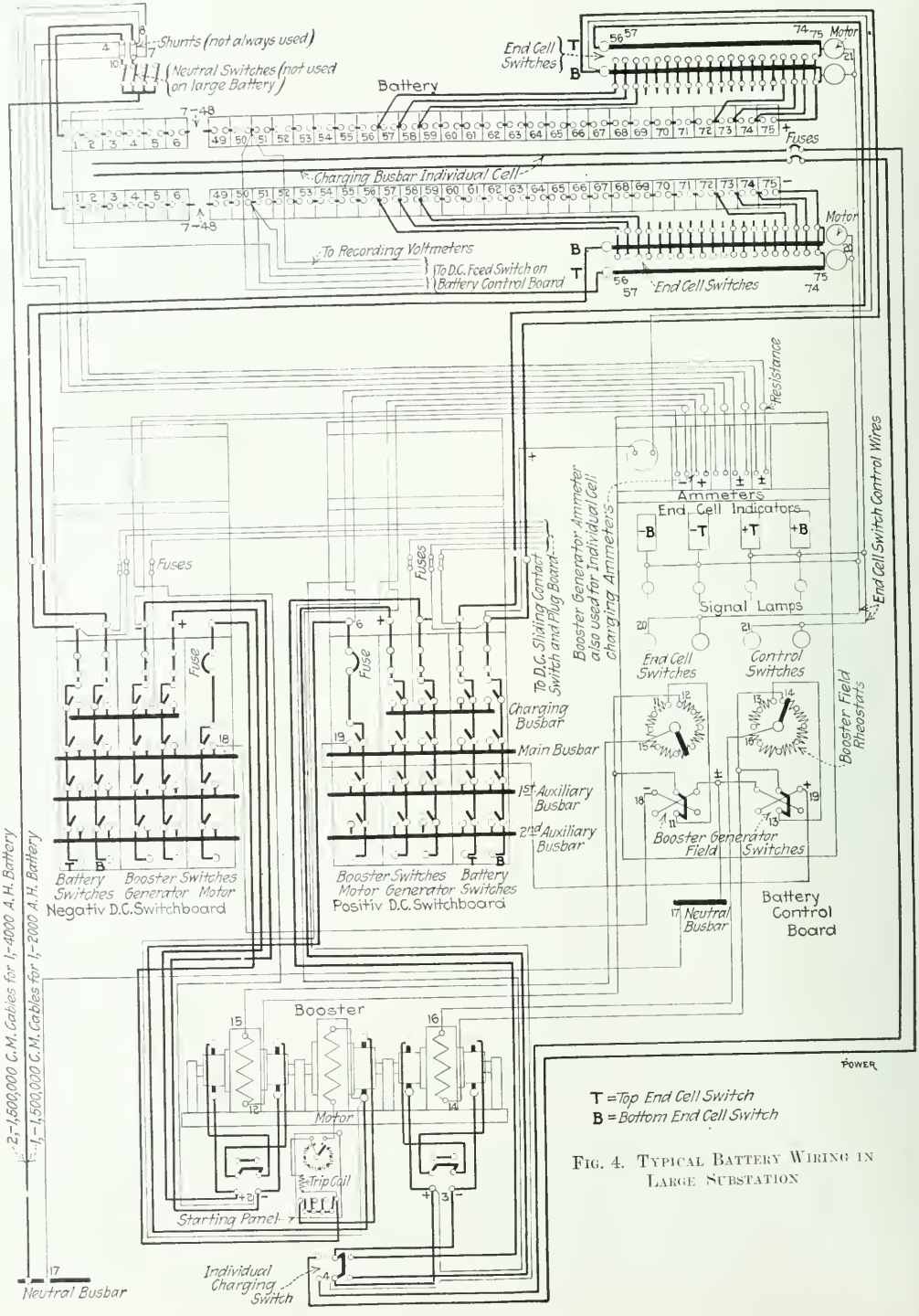


FIG. 4. TYPICAL BATTERY WIRING IN LARGE SUBSTATION

reversed and the voltage of the machine assists the battery in overcoming the opposing pressure of the main busbars sufficiently to deliver its current.

In Fig. 3 is shown a method of connection commonly used on substation batteries employed on a three-wire lighting system. The two booster generators are respectively connected in series with corresponding halves of the battery, the busbar connections for each half being made with an outside leg and the neutral. A detailed wiring diagram for this method is shown in Fig. 4.

The polarity of the booster is established, as required, by the field reversing switches shown on the battery control board. In addition to the booster, another means is provided for regulating the battery voltage. This consists of a number of units known as end cells, which are so arranged that they can be connected in series with the main battery circuit or disconnected therefrom without interrupting the continuity of service. This is done by means of sliding contact switches moved by threaded shafts driven by motors controlled from the battery control board. The arrangement of the end-cell switch connections, contacts, sliders and motors is shown in the diagram (Fig. 4).

It will be observed that the end-cell switches are provided with two sliders, a double set of contacts, and two main leads. There are several reasons for this: one is, to insure continuity of service by not making the latter wholly dependent upon one outfit. If only a single equipment were used and a vital part became out of order, the battery would be thrown out of service, whereas with a double equipment, if one line should be out of order the other could be used. Another reason is that a cross-section of copper is thereby provided, sufficient to meet the demands of the heavy currents involved, without incurring the inconvenience and extra labor necessary to incorporate this sectional area in a single line and one set of contacts.

Two small individual-cell charging busbars are shown extending through the battery room. These are so located that temporary connections can be made thereto from any cell in the room. They are for the purpose of charging independently of the main battery any cell which may have been found defective.

Care and Management

In the economical management of a storage battery, careful and systematic attention must be exercised in charging and discharging, replenishment of the electrolyte and cleaning and repairing in order to preserve the life and efficiency. The charge may be begun at about double the normal discharge rate for the first hour and gradually reduced to a low rate (say one-fifth normal) near the end. The current should be discontinued as soon as the charge is complete, which latter varies with the different types and depends upon the size and number of plates. Although a charge should be continued until both plates gas freely, if the charge is maintained too long, the gassing will cause the active material to be gradually loosened from the grids, breaking off and dropping to the bottom of the cell where it accumulates. If not removed, it will in time increase in depth until it comes into contact with the plates, thus causing an internal short-circuit. Moreover, excessive gassing causes the electrolyte to evaporate, rendering replenishment necessary more often than under normal conditions.

There are two methods commonly used in determining the proper duration of charge and discharge, namely, taking voltage readings and noting the specific gravity. When used in conjunction, they form a fairly accurate means of determining the time when the current should be discontinued. Upon charging, the voltage gradually rises. When it reaches a value of about 2.45 per cell, the battery can be said to be charged, providing a test of the electrolyte shows a specific gravity of 1.204. However, while the battery, as a whole, may show these average voltage and gravity values, the readings, when taken on the individual cells, may vary slightly, but will not be far from the average, providing the cells are in good condition. On the other hand, if any of the cells are sluggish, a pronounced difference will be noticed due to the incomplete reduction of the sulphate on the previous charges. These cells will require a longer charge than the others, but this is not necessary at every charging period.

An overcharge of the entire battery once every week or two, depending upon the frequency of the regular charging periods will generally be sufficient to reduce the sulphate remaining after normal charge and to thus even up the voltage and gravity of the individual cells. The duration of the overcharge is determined by voltage and gravity readings as in the case of normal charging. When these values reach a maximum and show no further rise in observations taken at short intervals over a period of an hour and a quarter, the overcharge should be stopped providing the battery is gassing freely. The maximum voltage attained upon overcharge will vary from 2.4 to 2.65 per cell, depending upon the age and conditions of the battery.

The same methods are used in the determination of the length of discharge as are used in the charge. The voltage, upon normal discharge, falls gradually, its drop being more rapid near the end. In general, the limit of discharge can be said to be about 1.75 volts per cell with current flowing at the normal rate. Moreover, the specific gravity of the electrolyte falls in proportion to ampere-hours discharged. The fall in specific gravity is dependent upon the quantity of solution as compared with the bulk of the plates. Ordinarily, if the specific gravity upon overcharge is 1.209, the limit governing the discharge should be about 1.174.

The battery should be regularly inspected to ascertain the condition of the cells. If any are found that compare unfavorably with the others in regard to voltage, color of plates or condition of the electrolyte, they should be given careful attention at once and watched closely until they return to their normal condition. A defective cell will not gas as actively as the others and its plates are usually lighter or darker in color than those of the other cells.

Careful use, an occasional cleaning and an early detection and removal of the causes of any abnormal conditions which may develop, will indefinitely prolong the life of the battery.

Locking Device for Disconnecting Switch

The illustration shows a locking device that effectively prevents the blade of a disconnecting switch from opening except under the direction of the operator. Instances are on record where the blade of a disconnecting switch

not protected by this device has been thrown open or partly open by magnetic repulsion and destroyed when a short-circuit has occurred on the line, not only resulting in the loss of the switch but also putting the circuit on which the switch was installed out of commission until a new switch could be installed unless there were duplicate circuits.

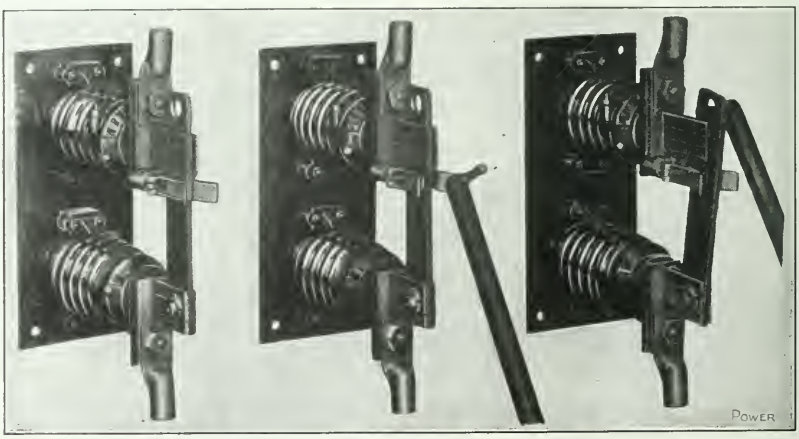
This locking device consists essentially of two brass bell cranks hinged together at the ends of the two shorter arms and held closed by compression springs. The projections or jaws in the outer ends of the two longer arms close in front of the blade, thus preventing the latter from coming out of the clips. Each bell crank is provided with a dog which moves in a slot in the bell crank's elbow, the dog being hinged at this point. Two compression springs, one pressing outward from the switch base against the elbow of each crank and also against the dog, keep the bell cranks closed and the dogs pressed against the back of the switch blade.

To open the switch, the outer ends of the bell cranks are pressed back away from the blade, allowing the dogs to come forward so as to rest upon the sides of the blade, in which position they hold the jaws in front of the blade apart, allowing the switch to be opened. Withdrawing the blade of the switch from between the dogs causes the jaws to automatically close against the sides of the blade and to snap shut as soon as the blade is completely withdrawn. These operations are shown in the illustrations.

As the outer edges of the jaws are beveled the switch blade can be readily pressed back in the clips into the closed position, when the jaws close automatically in front of the blade locking the latter in the closed position.

The operator does not have to remember to lock the switch closed, as it automatically locks itself, and thus guards against damage.

The device is made by the General Electric Co. in sizes to fit 300-, 600-, 800- and 1200-amp. switches. Since the safety catch is a unit in itself it can be applied to any G. E. type L-switch merely by clamping it to a support between the clip block and the insulator cap.

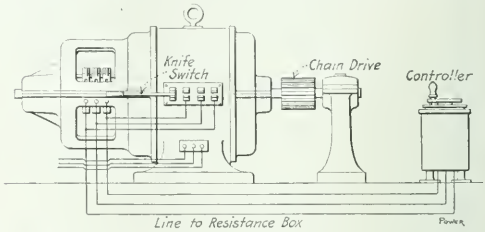


SWITCH IN CLOSED POSITION AND IN ACT OF BEING OPENED

CORRESPONDENCE

Short Circuiting Lines to Controller

We were bothered with the resistance becoming overheated in the controller of a 200-hp. induction motor driven from a 550-volt line. The heating was caused by bad contacts, which appeared to be in fair condition. To remedy this, wires were spliced onto the resistance wires and led to contacts on a board screwed onto the motor frame. On this board was mounted a knife switch. When starting the motor this switch is open, but when the motor is up to speed, and all the resistance is cut out, the knife switch is closed and short-circuits the line to the controller. The arrangement is shown in the sketch.



METHOD OF SHORT-CIRCUITING CONTROLLER WIRES

JAMES A. CAMPBELL.

Providence, R. I.

In a lecture before the International Congress of Applied Chemistry, New York, Sept. 11, 1912, Giacomo Cimician, of Bologna, Italy, stated that a square yard of the earth's surface receives each day (tropical day of six hours) an amount of heat equivalent to that in about 1.8 lb. of coal. A square mile would therefore receive each day heat equivalent to the combustion of over 2600 tons of coal. The quantity of coal and lignite mined annually in Europe and America is about 1,100,000,000 tons, and an area of about 1200 square miles—that of a fair-sized American county—receives during the year from the sun an amount of energy equivalent to that obtainable from this coal output.

GAS POWER DEPARTMENT

Diesel Engine Driving Rolling Mill

By Dr. Alfred Gradenwitz

The 450-hp. Diesel engine plant of the Achenrain Brass Works, at Kramsach-Achenrain, Northern Tyrol, is of special interest on account of the particularly unfavorable working conditions to which the Diesel engine has in this case been adapted. This firm in 1909 installed a 700-hp. water turbine of the Francis type, utilizing the water power of the Brandenberger Ache. The energy was conveyed by a high-tension transmission line to the rolling mill situated about one mile distant. The variations in the amount of available water, however, induced the managers to install a Diesel engine as a standby.

Fig. 2 represents the load in rolling and pressing during two consecutive pressing processes and simultaneous fact that the speed does not decrease during the maximum performance had to be taken into account. Also, an ample overload capacity of the motor had to be provided.

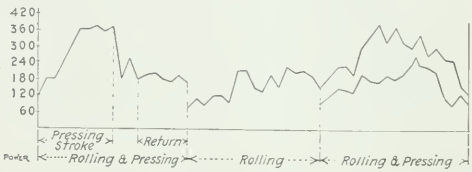


Fig. 2. Showing Variation of Load

To provide for sudden variations in load, an exceptionally heavy flywheel had to be included. This is of cast steel, 16 ft. in diameter. Its rim weighs approximately

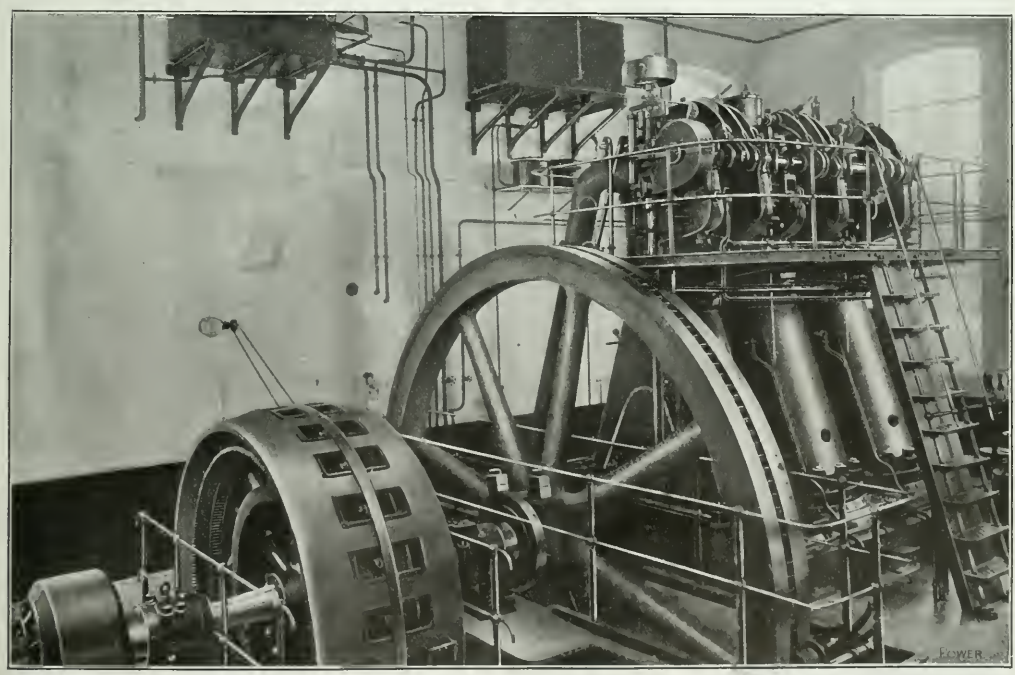


Fig. 1. Diesel Engine and Generator

rolling on five frames. The fluctuations attending this rolling and pressing process are seen at a glance; those corresponding to the switching in of the huge hydraulic press, where rods are pressed hot out of the ingot, are as high as 300 per cent., being close to 400 hp. The maximum loads as well as their duration are variable, depending on the resistances met with in the press and on the temperature of the ingot. In designing the engine the 11 tons and the total weight of the flywheel is 90 lb. per engine horsepower.

The Diesel engine is a three-cylinder four-stroke-cycle machine the cylinders being 20 in. in diameter and 30-in. stroke and the normal speed 168 r.p.m. It is coupled direct to a three-phase generator supplying the motors which drive the rolling mill. The engine is of normal design, but in view of its special purpose and its overload

capacity it is built particularly heavy. The compressor is mounted on the shaft of the generator.

In connection with tests made on delivery, the crude-oil consumption of the Diesel engine at full load was found to be 0.432 lb. per hp.-hr. This rather high figure was due mainly to the fluctuations in load, which occurred during the test. The slowing-down time of the engine was found to be 4 min., 50 sec., and with the suction valves lifted, 8 min., 52 sec., which shows small friction. Its mechanical efficiency, inclusive of the compressor, was 75 to 79 per cent. The thermal efficiency

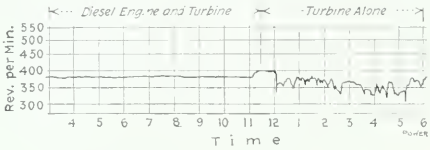


Fig. 3. Speed Regulation

was found to be 32.2 per cent. at full load, and 28.1 per cent. at half load.

Fig. 3 shows a tachometer record at the power station during a typical night load. Until 11 o'clock the Diesel engine ran in parallel with the water turbine, but after this time only the turbine was kept in service. Although the working process at the rolling mill was quite identical before and after 11 o'clock, the record shows that before this time there were no appreciable fluctuations in the speed, the Diesel engine effecting perfect compensation. The second part of the diagram, which corresponds to exclusive turbine operation, shows the speed variations to which the turbine was subjected.

Last summer this installation was put to a decisive test, the turbine generator windings being burnt out by lightning, so that the Diesel engine during ten weeks had to supply continuously all the power to the works.

The Low Coal Engine

The direct utilization of coal in a gas engine forms the basis of an invention by Dr. A. M. Low, which is attracting considerable attention in England. Speaking generally, Dr. Low's engine occupies a position in the

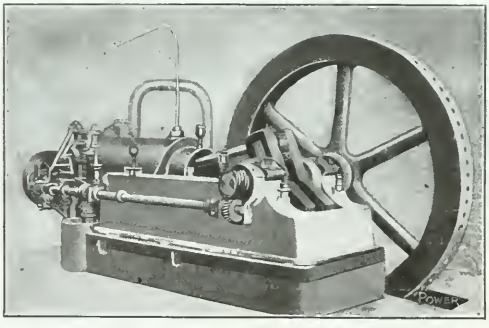


Fig. 1. The Low Coal Engine

gas-power field very similar to that of the locomobile in steam-engine practice; that is, it is a self-contained unit for converting the heat in the coal into mechanical energy at the engine shaft. Of course, it has not yet attained the refinements of the locomobile and is still in a more or less experimental stage. The important fact is that it runs successfully and is claimed to have produced a brake horsepower-hour on about ½ lb. of coal—a remarkable performance, if true.

The present engine, which is rated at 100 hp., is shown in Fig. 1, and Fig. 2 represents a section through the coal-feeding device at the head end.

Referring to Fig. 2, coal is fed into the hopper *A* from which it is conveyed by four worms through the heater tubes *T*. These tubes pass through the gas chamber *G*, connected with the inlet valve, the exhaust heated chamber *E*, the combustion chamber *C* and open into the ash and soot chamber *S*. The latter is fitted with a nonreturn valve which admits air or a mixture of steam and air to the tubes. This air is drawn by the suction of the engine over the incandescent coal, maintained in this state by the heat of chambers *C* and *E*, and passes through holes in the tubes *T* into chamber *G*. It is by this time

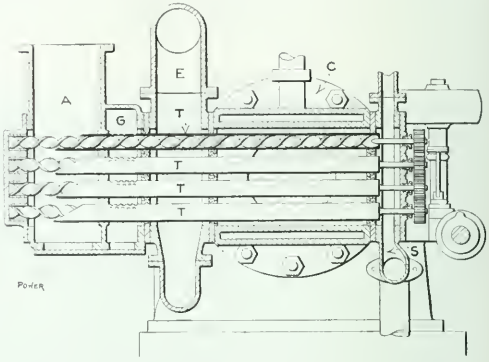


Fig. 2. Section through Coal-feeding and Gas-forming Device

mixed with the gases given off from the incandescent coal and the mixture passes from chamber *G* through the inlet valve into the cylinder of the engine.

In starting, the coal is brought up to incandescence by running for a few minutes on illuminating or other available gas.

The feed of the worms, which are driven through gearing at the right, may be adjusted to suit the load, and the coal after it has given off all its gas is discharged as ash into the bottom of the ash shoot *S*.

With no gas-cleaning apparatus one would expect to encounter trouble from the tar. No such trouble has been experienced, however. This, Dr. Low ascribes to the fact that the coal is heated rapidly and in small quantities; hence the tar is not gasified but passes off in the form of fine yellow dust. The high temperatures and relatively low compression, about 90 lb., prevent these fine particles of tar from being condensed and precipitated in the engine passages; hence they pass off as yellow smoke in the exhaust.

R. F. Halliwell, in a paper upon "Recent Developments in Curtis Steam Turbines," read before the Manchester Association of Engineers, says that in the Curtis turbine as built by the British Thomson-Houston Co., at Rugby, England, it is usual to provide about ⅛-in. axial and ⅜-in. radial clearance.

Vaporizers for Producers Using Wood Fuel

A claim is made by builders of certain suction-gas generators using wood for fuel that, on account of the moisture in this class of fuel, it is unnecessary to incorporate a vaporizer for enriching the gases.

In these generators the air is drawn in beneath the fuel column, and the fuel is fed from above, as a consequence of which the temperature varies from that of the highly incandescent fuel at the bottom to that of the comparatively cold fuel near the hopper. The temperature at which the gases pass the last fed fuel will be insufficient to more than vaporize the moisture in this fuel, which will pass off as steam along with the gases. Even were the vapor decomposed, the oxygen, meeting no carbon at this point, would pass away in a free state.

To the writer, it would appear then that the claims made have no support in fact. In the first water-gas plant erected in England, a similar argument was advanced as the forerunner of a distinct improvement. In this producer the steam was first admitted above the fuel, and as a consequence the latter became so impregnated with moisture that it was difficult to drive off the moisture during the next blow. Hence it was found unprofitable to use the gas for furnace work, and it was allowed to blow into the atmosphere—a dead loss of millions of cubic feet, besides being the source of much complaint from the people of the surrounding district.

With a view to rendering possible the utilization of the producer gas, the steam arrangement was modified to permit the steam being admitted below the fuel column. This proved successful.

The moisture in the fuel of a suction plant would have a similar influence in weakening the gases as had the saturated fuel in this water-gas plant. With much moisture and consequent extreme vapor production, the gas production would be considerably lessened, the suction from the engine being not much more than sufficient to draw off the vapor, which, of course, would be condensed in the scrubber.

It is probable that a damp coal is responsible for the difficulties occurring at times in suction plants, particularly at the commencement of a run.

Manchester, Eng. FRANCIS W. SHAW.

Consuming Gas Engine Smoke

Gas engines are often fitted with crank-case relief valves which sometimes allow considerable smoke to escape. The three engines of which I have charge made the air blue until we put in 1½-in. pipe from the relief valve of each engine to the 4-in. intake pipe. At the lowest point in the 1½-in. line we arranged a ¼-in. line to drain off the small quantity of oil which is apt to get past the relief valve. This arrangement allows the smoke to be consumed in the cylinders, keeps the engine-room air fit to breathe and the mixing valves do not need any more cleaning than before.

Kane, Penn. FLOYD L. FRAZINE.

Gas Engine Troubles

BY H. LOCKE

Difficult starting	Incorrect mixture	Mixture too weak owing to insufficient gas	(1)
		Mixture too rich owing to insufficient air	(2)
		Tube not properly heated	(3)
		Timing valve incorrectly adjusted	(4)
	Defective ignition or failure to ignite	Vibrator out of adjustment	(5)
		Sparking plugs too far apart or dirty	(6)
		Wire disconnected or short circuit	(7)
		Batteries weak or coil defective	(8)
	Engine too cold; see lines (9) and (10).		
	Incorrect mixture; see lines (1) and (2).		
	Defective ignition; see lines (3) and (8).		
Lack of power	Engine too cold	Jacket water turned on too freely or too soon	(9)
		Water lodging in cylinder, leaky jacket joint	(10)
		Defective circulation of cooling water or insufficient supply	(11)
		Faulty lubrication	(12)
	Engine too hot	Exhaust cam worn, causing insufficient opening of exhaust	(13)
		Mixture too rich	(14)
		Too high compression owing to carbon deposit	(15)
	Leakage during compression	Piston rings worn or sticking in grooves	(16)
		Liner worn or grooved	(17)
		Leaky valves	(18)
	Ignition too late.		
Pounding and knocking	Parts of engine loose or worn	Connecting rod or main brasses slack	(19)
		Flywheel loose	(20)
	Moving parts striking an obstruction		
	Broken piston ring.		
	Spark advanced too far		
	Spark too early.		
	Cylinder and piston overheated; see lines (11) and (15).		
Preignition	Too high compression		
	Glowing carbon or metal points in the cylinder and burning gas	Pockets for gas to accumulate	(21)
	Ignition uncertain.		
Backfiring	Delayed burning of previous charge	Pockets for gas to accumulate	(21)
	Incorrect mixture	Too much air	(22)
	Valve timing wrong, inlet late in closing		
	Leaky inlet valves.		
Explosion in exhaust pipe	Accumulation of unburnt gases	Previous charge too rich	(23)
		Ignition uncertain	(24)
	Exhaust valve leaky	Valve or seat bad	(25)
		Dirt under valve face	(26)
		Weak spring	(27)
	Exhaust opens early	Incorrect timing	(28)
		Gasometer body balanced or rusted in guides	(29)
	Variation of gas pressure	Irregular working of plant	(30)
		Leakage of air in producer	(31)
Poor speed regulation	Pallets on striker worn		
	Governor stiff or worn	Want of lubrication	(32)
		Poor adjustment	(33)
	Incorrect mixture		
Excessive fuel consumption	Engine too cold; see lines (9) and (10)		
	Leakage; see lines (16–18), and (25–27)		
Smoke	At end of exhaust pipe	Mixture too rich—smoke black	(34)
		Excessive cylinder lubrication—blue smoke	(35)
	Past piston.		

HEATING AND VENTILATION

Condensing Plants for Large Commercial Buildings

By Ira N. Evans

It is remarkable that in recent years little or no change has occurred in methods of heating large commercial and office buildings. Many new appliances in the form of thermostatic and float traps for use on the individual radiators of vacuum systems have appeared, which have merit and are designed to prevent the vacuum from communicating with the heating system proper. Little or no progress, however, has been made in utilizing the condensing capacity of a heating system to reduce the steam consumption on the engines by operating on pressures below atmosphere at the exhaust outlet of the machine.

It is almost impossible to make a large steam-heating system air-tight on pressures below 10 in. of vacuum. Yet there are numbers of large heating systems that require 300, 400 and even 1000 hp. and have a cooling or condensing effect to that extent.

In manufacturing plants where water is scarce, cooling towers are used extensively and with success. The cooling tower is a device for mechanically evaporating a portion of the injection water and thereby lowering its temperature so that it can be utilized over and over in a surface condenser.

The tower may be placed on the roof or in the basement and the water circulated between the tower and condenser by a pump, the head on the pump being that due to the friction of the piping and the height of the tower. There are several forms of cooling tower embodying the principle of bringing air in contact with a film of water in order to assist the evaporation. The quantity of air required depends on the area of water surface presented, and the hotter the air and the lower its humidity, the better its absorbing power. Convenient sources of hot air are the engine and boiler rooms. Ventilation of these rooms might be readily effected by drawing the hot air to the tower, and thus combining two operations in one. Where the building is high, a good flue will furnish natural draft at slight expense.

There are few office buildings that do not have a peak lighting load 100 per cent. greater than the average power load, and many buildings have 100,000 sq.ft. of radiation which would have a condensing capacity averaging 20,000 lb. of steam per hr. This surface is designed to operate at or near 212 deg. in zero weather on account of possible back-pressure and could be operated at 150 or 160 deg. and 20 in. of vacuum 75 per cent. of the heating season if it were possible to make the steam system air-tight. It is readily seen that an engine operating against 20 in. of vacuum is far more economical than when operating against 3 lb. back pressure or perhaps atmospheric pressure.

When hot water under forced circulation is used for heating, the necessity of making the system air-tight disappears, except in the short steam line to the exhaust heater and the steam chamber of the heater. The hot-water system then becomes an adjunct of the condenser to produce vacuum on the engine, if not allowed to become overheated, and thereby reduces the capacity in condensers which would ordinarily be required.

When a condensing plant is proposed for an office building, it is at once asked where the water is coming from and what it will cost. An accompanying remark is that steam is required for heating seven months and the saving by operating condensing the other five months would not pay the interest on the investment for condensing equipment. With a steam system this may be true and yet many cases occur when 1000 hp. in exhaust is thrown away when the maximum that could be used on the heating is 500 hp. This calls for a total installation of 1500 hp., which condensers would reduce considerably.

If it will pay to operate 1000 hp. condensing with a cooling tower in Oshkosh, there is no reason why it will not pay in New York, especially when it can be combined with heating, ventilation and other necessary operations.

When the condensing equipment can be considered, the turbine occupying one-half to one-quarter the floor space required by a reciprocating engine becomes an object of interest. In connection with hot-water heating it can be operated at high economy, but with a vacuum steam system its steam consumption would be prohibitive. The average daily power load nearly balances the heating in buildings of this character in zero weather and can be made to balance it at all outside temperatures with hot water by varying the vacuum. The peak lighting load, during which the excess exhaust steam is generally thrown away, can be operated under full vacuum. The condensing capacity required for the peak lighting load in winter will about take care of the summer load where no heating is operative. In a 1500-kw. plant only 1000 kw. in condensing capacity will be required to carry vacuum at all times if there are 100,000 sq.ft. of hot-water radiation to take care of the extra 500-kw. load in winter. The radiating surface required need be no greater for the hot-water system as the surface in both systems for zero weather may be based on a temperature of 212 deg. in the radiators.

There should be no insurmountable difficulty in finding space for the cooling tower, as all large buildings have more or less undesirable space either in the basement or on the roof that can be used. In the basement the space saved by the installation of turbines would go a long way in making room for the tower.

As to the amount of water used in the plant there will be a saving by the installation of a condenser and cooling tower. An average water rate at the switchboard would be for noncondensing conditions 32 lb. per kw.-hr. This amount for the load not required for heating is usually wasted to the atmosphere. A cooling tower requires about 1 lb. of water per pound of steam condensed

If the water rate for full vacuum is 21 lb. per kw.-hr. at the switchboard then 21 lb. of water will be evaporated to the atmosphere from the tower, while the 21 lb. of condensation will be returned for boiler purposes. This makes a net charge of 21 lb. per kw.-hr. instead of 32 lb. for that part of the load in excess of the heating load. Where the peak or excess power load over that required for heating is 500 kw. or more, the saving in water would be a considerable item.

Where the hot-water heating system is combined with the cooling tower there will be only a few hours in the year when some vacuum cannot be carried on the heating load, and full vacuum can be carried summer and winter on all power except that required for the heating system.

If a driven well is available, although the water may be unfit for boilers, it would be all right for make-up water for the cooling tower, and a limited flow would be sufficient. Only a small percentage of city water would be required as the condensation in the condenser would be saved.

If some of the real-estate operators could see this it would make some building operations pay where there would be a deficit under the present arrangement. It is a well established fact that a condensing plant is 25 per cent. more efficient than a noncondensing plant, and that hot-water heating with a variable temperature is 25 per cent. more economical than a steam system operating at a constant temperature without heat control. If a building used $20,000 worth of fuel per year under the exhaust-steam heating method, the saving by forced hot water with condensing equipment would be $5000, which would be sufficient to pay the interest on a $100,000 mortgage at 5 per cent. At the same time 25 per cent. of the boiler capacity could be omitted with the attendant saving.

When automatic heat control is applied to a steam system there would be no saving during periods of surplus power load, as the same amount of steam would be generated whether utilized or not and more would be thrown to the atmosphere than if heat control were not applied. The same is true of a hot-water system if the condensing feature is not installed. Heat control on steam and forced hot water will, however, enable a saving to be made at night and periods when the steam for heating is in excess of that furnished by the power.

With a turbine unit on hot-water heating the same load within 10 per cent. can be carried from September to May and just enough steam furnished to provide for all outside weather changes from 0 to 70 deg. by simply varying the vacuum. This has been demonstrated in actual practice. Overheating of the rooms will be eliminated and there need be no occasion for opening windows and wasting heat to the atmosphere.

There is no limit to the height of a building to which this system may be applied as the system could be divided into independent units at varying levels in order to limit the static head to the commercial working pressures of the apparatus. It is impossible to obtain the maximum power economy with a hot-water system operated in this manner, when the power load furnishes an excess of exhaust steam, without the cooling tower, even when it has little or no work to do. Where the heating requirements are in excess of the power load it is of slight importance what may be the water rate per kilowatt-hour, so long as the heating system utilizes the steam exhausted.

Hot water has been used in many places where long distances were the deciding factor over low-pressure steam. If it is feasible when the system is spread over a large area, why not when extended into the air, dividing the system into units at varying levels?

If cooling towers and condensing equipment will pay without any heating system with cheap coal and a spur track into the plant, why will it not pay in an office building with expensive coal, a heating system to take part of the duty and a ventilating chimney high enough to provide natural draft for the cooling tower. In many cases a fresh air supply for ventilation in connection with a hot-water system will reduce the size of the cooling tower still further.

When a portion of the equipment is operated condensing with a cooling tower, the logical heating system will be hot water, and by means of it the remainder of the power equipment may be operated under partial vacuum, so that condensing conditions may be maintained at all seasons.

All of the operations mentioned previously are individually common practice and standard machinery is available. It seems a logical conclusion that if they will pay separately they should give better results when combined in one installation. The same limit governs the condensing engine here as elsewhere; that is, a size that will give sufficient return to pay interest and depreciation on the extra equipment. The minimum load would be about 200 hp. for a fair percentage of the year. It seems inconsistent for engineers to recommend cooling towers and condensing equipments for plants in one locality and yet waste steam at a higher rate in plants of equal or greater capacity where the conditions for condensing are more favorable.

CORRESPONDENCE

Water Leaves Boiler

The heating system in the school in which I am employed is supplied with steam by three sectional cast-iron boilers set to blow off at 15-lb. pressure. It takes too long to get up heat as I cannot let the fires go full draft over 20 or 30 min., before the return pipes will start kicking. Then the water begins to leave the boilers, requiring closing of the drafts for a short time to allow the water to return. Then the drafts are turned on again and the same operation repeated all day. When the drafts are closed there is about ½-lb. pressure and quite often the radiators in the wing of the building are cold. The building, which is three stories high, is 200 ft. long and 65 ft. wide for 110 ft., the other 90 ft. being 50 ft. wide.

The boilers are at the middle front with a 3½-in. supply pipe running each way and also a 3-in. pipe running over the boilers to the wing at the back. It is a one-pipe system with return pipes ¾, 1 and 1¼ in. near the boilers, except for the back wing which has a 1¼-in. return all the way. I would like to know the cause of the trouble and hope POWER readers can help me out.

LUTHER WALLING.

Brantford, Ont., Canada.

Heating a School

In an article in POWER of Dec. 10, by Fred L. Wagner, there are several calculations with which I do not quite agree; at least, I think there may be a better way used to arrive at the desired results.

As 56,000 cu.ft. of air per min. are to be used for ventilating purposes, this air must be raised from outdoor temperature to 70 deg. as given, but this air will have to be raised to a still higher temperature in order to take care of the 1,122,100 B.t.u. per hour loss from the walls, etc. Letting T be the final temperature required and 70 deg. the temperature of the room, gives

$$T = \frac{55 \times 1{,}122{,}100}{56{,}000 \times 60} + 70 = 88.5 \; deg.$$

Allowing 6.5 deg. drop due to radiation losses from the piping between the heater and rooms, a final temperature of 95 deg. leaving the heater will be required instead of 120 deg. as suggested by Mr. Wagner.

From tables furnished by the Buffalo Forge Co., I find that their heater 20 rows deep with a velocity of 1200 ft. per min. through the heater will raise the temperature of the air from 0 to 97 deg.

Allowing a velocity of 1200 ft. per min. through the heater, a clear area of

$$56{,}000 \div 1200 = 46.6 \; sq.ft.$$

will be required, and using two sections back to back the clear area of each will be 23.3 sq.ft., that is, the heater will be 20 rows deep with a total clear area of 46.6 sq.ft. Referring again to the tables, the square feet of surface in the ten four-row sections will be 2900 sq.ft. instead of the 5400 sq.ft. allowed by Mr. Wagner. While extra surface is often added to the heater to allow for rapid heating, in school work it is much better practice to so arrange the system that the air may be recirculated when warming up in the morning.

Using 2 lb. of steam condensed per square foot of heating surface gives

$$\frac{2900 \times 2}{34.5} = 168 \; boiler \; hp.$$

The ten four-row sections of the 7x7-ft. 4-in. heater will contain 8450 lin.ft. of 1-in. pipe and under the conditions assumed will deliver 706 B.t.u. per lin.ft. per hr.

$$\frac{8450 \times 706}{960 \times 34.5} = 180 \; boiler \; hp.$$

This practically agrees with the editor's note in connection with the above article, and the editor's method is really the correct way to determine the boiler horsepower.

The sizes of fans and engines given by Mr. Wagner are correct for the conditions he has assumed. The velocity through the heater, 1200 ft. per min., is too high for school work, as is also the resistance of ¾ oz. assumed for the fan. By lowering the velocity through the heater to 1000 ft. per min. the resistance will be only 69 per cent. of that at 1200 ft., thus reducing the pressure at the fan. The conditions assumed would be all right for a shop but would in all probability prove too noisy for a school. By using a size larger fan at ½-oz. pressure both the speed and horsepower will be greatly reduced. Using two blowers, each with a 90-in. wheel at 170 r.p.m. will require only 8 hp.

FRANK L. BUSEY.

Buffalo, N. Y.

Rearranging Heating Coils

In the issue of June 11, page 842, I showed a sketch, Fig. 1, of a coil used for heating one part of our factory and with which we had trouble last winter. I also asked the readers for an improvement over the method shown in Fig. 2. The 200 ft. of pipes were cut into three sec-

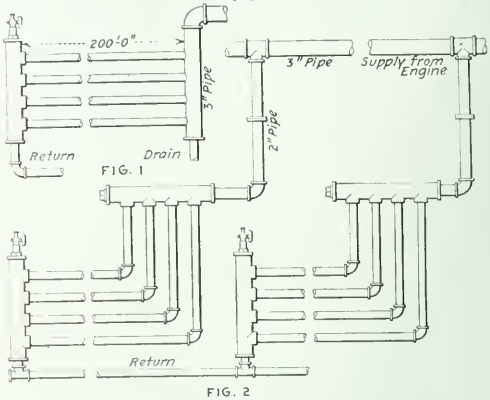


FIG. 2. PROPOSED ARRANGEMENT OF COILS

tions. In Fig. 3, two of the three sections are shown. The supply pipe was run to the last section, with a valve near each section. To allow for expansion and contraction the branch tees are connected to the coils, as shown at *A* in Fig. 3.

A separate drip is run from each section. To allow for expansion in the feed line to the coils the branch pipe is arranged as shown at *B*, Fig. 3. This system has been in use for about six weeks, and I believe that there will be no trouble this winter.

A short time ago a number of second-hand steam

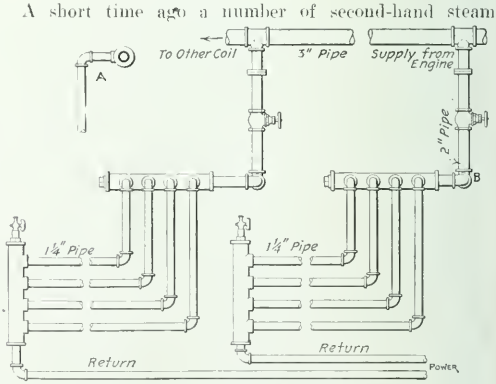


FIG. 3. COILS AS FINALLY ARRANGED

radiators were bought to be used in the new office, but in the lot there were none large enough to furnish sufficient heat for two rooms, each requiring 100 sq.ft. of heating surface. There were four radiators of 50 sq.ft. in the lot. So I decided to connect two of them together with a 2-in. close nipple. This did away with connecting each radiator separately to the supply and return lines.

H. A. JAHNKE.

Milwaukee, Wis.

EDITORIALS

Commercial Building Heating

What are the reasons for the present practice in the heating of office buildings, stores and the like? The common tendency is to operate the power plants noncondensing, in the winter at least, and to use the exhaust steam under some pressure above atmospheric in the heating system. Greater back pressure on the engines means higher steam consumption, and so long as the extent of the heating requires the latter, it is justifiable. Then in a sense the engine is merely a reducing valve and the power generated a byproduct. If, however, the engine load is such that more than sufficient exhaust steam is available and some must go to waste, there is a corresponding loss of economy.

A compromise is the use of the vacuum-heating system, thus reducing the back pressure on the engine and consequently the steam consumption not only by lowering the initial pressure required on the heating system, but also by taking advantage of the condensing capacity of the radiation. This arrangement would be more successful were it not for the difficulty of keeping the heating system sufficiently tight. Where it is practically impossible to keep the entire heating system air-tight, it is not a difficult matter to maintain a vacuum of over twenty inches in a short exhaust pipe and the heater of a hot-water system. Where the power balances the heating in zero weather, it would be possible to run under considerable vacuum for five out of the seven months of heating and at full vacuum the other five months of the year. Blowing the exhaust to atmosphere from hundreds of horsepower at a rate approaching forty pounds per kilowatt-hour is by no means economical. A rather strong argument for a condensing plant in connection with hot-water heating as the solution of the problem, is put forth in an article on page 88. It is contended that this combination would reduce the steam consumption one-third, and by the use of a cooling tower the amount of water for the plant would be reduced in the same proportion.

With a condenser of the surface type, water unfit for boiler use might be circulated through the cooling tower and the water drawn from the city mains reduced to a negligible quantity. In a year's run the cost of water is an important item and another is the possible reduction in boiler capacity by operating condensing. These two items as well as the saving in steam consumption, must be balanced against the investment over and above the cost of an ordinary noncondensing, exhaust-steam-heating plant.

Where power is required to any extent in the building, the exhaust steam will be considerably in excess of the demands for heating. In such a case one of the units in the plant could be made to cover the heating and operate under partial vacuum, while the others could be operated at full vacuum. As a matter of fact this same arrangement might be applied to the ordinary noncondensing plant. That part of the load in excess of the heating might be operated condensing, or even at atmospheric pressure. There is no occasion to impose three pounds back pressure or perhaps more on the entire system, when a saving worth while in some cases might be effected.

There is much to be said on the other side, and it is hoped that those in a position to discuss this question authoritatively will do so. As stated in the article the discussion does not refer to plants carrying a normal load under two or three hundred kilowatts. There must be reasons why so many engineers favor the present commonest practice. Let us have them, as the subject is well worth a little attention.

One Way to Know

Failures can be counted by hundreds in the immediate vicinity of most of us. Projects which looked promising to the individuals who had spent hours thinking about them, were failures from the start.

Engineers have found plant conditions such that it was evident, even to the inexperienced, that something was wrong, but what to do to remedy the trouble was a mystery. Remedies that could not possibly prevent the trouble have been tried, while at other times nothing was done, because the engineer did not know what to do.

In one instance the rear tubes of a return-tubular boiler began to leak. This was a perplexing experience to the engineer in charge, who was new to the work. He had no idea as to the cause, but was told it was because of an accumulation of scale on the rear head and around the tubes at the back end. As a matter of fact, scale did have something to do with the trouble, but it was mainly due to blowing down the boiler while under steam pressure, washing it out with cold water, refilling it and raising steam in the shortest possible time, sometimes not more than an hour being taken to do so.

This man did not know any better than to abuse the boiler, and instead of removing the scale and taking a longer time to generate steam from cold water, the scale was allowed to remain on the tubes and head, and steam generated in the quickest possible time. Now this engineer was ignorant concerning the damage he was doing the boiler, not because nothing had been published regarding the evil effects of scale, of hastily generating steam or of forcing the fires under a cold boiler, but because he had not read what had been published regarding these subjects.

In another instance a pump would not pick up water, due to a high suction lift and no foot valve on the suction pipe. It required the service of a pump man to remedy the matter, who put in a foot valve. The engineer knew where the trouble was, but did not know how to remedy it. Another case of not reading what had been published regarding the subject.

These two incidents bring us to the point at issue; lack of knowledge, due to lack of reading. Some engineers are like the small boy in the first grade of the day school, who wanted his father to write down a few prob-

lems in arithmetic. When the boy found that they were a little more difficult than those to which he had been accustomed, he threw down his paper, saying they were too hard and not what he wanted. Sums of two and two, etc., would have been easy, but useless, because the boy already knew them.

Are not many engineers in the same class with the small boy? Is it not a fact that they do not think it necessary or of advantage to themselves to read articles dealing with engineering subjects with which they are not familiar?

Do they realize that an article relating to some engineering features foreign to the plant they operate may be of such character that the information gained from reading it may be of much value in after years? There are many engineers who have profited by such reading long after the article had been destroyed and apparently forgotten.

In this age of progress the man who expects to keep pace with the times cannot expect to learn everything for himself by experience; he must take advantage of the published experiences of others. It will save mistakes, and much overtime and discouraging hard work.

⁂

Should the Engineer Be Factory Fire Chief?

Due to the heavy losses of life and property by fire in recent years, the need of means, compulsory and volitional, for fire prevention, is justly emphasized.

When thousands of workers, most of them females, are housed in one, or at most, a few buildings and particularly if the product manufactured is highly inflammable, numerous and unobstructed exits, alarm systems, fire pumps and other fire defensive equipment, and regular fire drills become a necessity.

The factory fire chief who usually directs this part of the organization and cares for the mechanical and electrical equipment should, besides being a good organizer, be a man of mechanical training and ideas. So much of the fire preventive and fire-fighting equipment comes within the engineer's department that he, in many places, is selected by the management to act as factory fire chief. No doubt the selection is logical, for, besides being qualified to competently care for the necessary mechanical and electrical equipment, he is, generally, the best man to work out new devices and improvements which conduce to a higher effectiveness of the fire-fighting system.

The appointment of the engineer as factory fire chief has its disadvantages. The thing to remember is that he is responsible for the power plant and often his whole time must be devoted to such duties. Furthermore, the additional equipment for fire prevention and fighting increases his duties because he alone is capable of caring for such equipment. The proper care of sprinkler system, extinguishers, alarm systems, pumps, etc., is all that should be expected of the engineer in addition to his regular work.

Let someone with less exacting duties and with character and judgment equal to that of the engineer be appointed factory fire chief to take charge of the fire drills, etc. The logical relation of the engineer to this department should be as adviser regarding the necessary mechanical equipment. To expect him to care for a large plant and assume the functions of the factory fire chief, and maintain both departments in a state of high efficiency is too much. Where the plan is tried it is likely to result in both departments being too much neglected.

⁂

Discussion of Engineering Subjects

In this issue, page (94) we print a letter from a contributor who tells of a progressive company that formed a reading club in its engineering department for the purpose of discussing articles that appear in engineering papers. The members are assigned to papers and make abstracts of articles most suited to the club's purpose. After the abstract is read and discussed it is filed for reference.

The many advantages of such a plan are at once apparent. Perhaps other companies will form such clubs if their engineers work toward that end. The letter reminded us chiefly of the deplorable lack of discussion on subjects valuable to every engineer by most engineering societies.

Among some societies composed mostly of the rank and file of practical power plant men, there is a dirth of such discussion that is positively inexcusable. After attending many meetings one gets the impression that the organization has entirely missed its fundamental purpose.

The social end of an engineering organization is of great importance, but if the bulk of attention is centered on this feature the charter ought to be revised to apply to a glee club. Every engineer, however competent, meets with perplexing experiences that are of interest and value to every other engineer. Many engineers are confronted with problems that they find it difficult to master without assistance. At the meetings and through the power-plant papers, these experiences and problems should be related and discussed so that practical benefit to a large number may come of them.

If more time was thus spent instead of taking up the evenings with parliamentary quibbles, and good, but too much entertainment, the purpose of the organizations would be better realized. It would seem a suggestion worthy of consideration that such organizations make it a practice of carrying out some such plan as that described by our contributor.

⁂

Bourne's "Handbook on the Steam Engine," published in 1866, contains (page 154) the following interesting table:

At the atmospheric pressure, and starting at 212 deg. F., the following estimates of the latent heat of steam have been formed by the best authorities:

Watt	950	Despretz	955.8
Southern	945	Regnault	966.1
Lavoisier	1000	Fabre and Silbermann	964.8
Rumford	1008 3		

Regnault's estimate was then regarded as the most accurate. He is also credited with giving 965.7 as the latent heat of evaporation. Today the generally accepted value is 970.4, as given in the Marks & Davis steam tables.

⁂

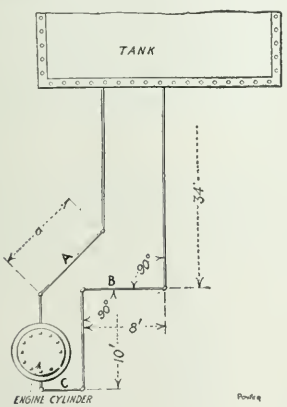
The index for the second half of POWER for 1912 will be mailed with the Jan. 28 issue.

READERS WITH SOMETHING TO SAY

Gas Engine Jacket Water Piping

A gas engine had to be cooled with water from a large tank 50 ft. above it. It was decided not to waste the water but to return it to the tank where the few added heat units would do no harm in the body of constantly replenished water. Since this tank would sometimes be nearly empty, it was not desirable to add an upstanding length of pipe to insure that the circulation should be always one way.

The instructions given to the pipe fitter were to install both rising and down pipes shaped as the pipe *A* so that the whole length of each pipe would have no horizontal length in it except the unavoidable length at *C*. Instead of doing so he connected them shaped as pipe *B*, which



Connections for Gas-engine Jacket Water Circulation

has a horizontal piece of several feet and with elbows at all turns. The down pipe *B* was left thus, but the rising pipe *A* was made larger, all its bends were made large and the length *A* was inclined as shown.

Assurances were given by some that the water could not circulate, though they could offer no reason why. When the engine began to run it upset their calculations entirely, for the circulation was more than sufficient. But it also upset my notions, for the pipe *B* was the hot pipe, and *A* was the supply, while water flowed into the top of the jacket and out at its base. This did not matter for the object sought was attained, although it did not last. Sometimes the circulation goes one way, at others it goes the opposite.

The larger pipe *A* was intended to help the warm water to get away freely, but the circulation seems to select either way indifferently, and I am by no means sure that the supposed wrong way around is not the better way for the cylinder, for it tends to a better cooling effect on that part of the cylinder toward which heat is supposed to tend, and on which the lubricating oil is least inclined to stay. The flow is throttled to keep the jacket thermometer at 120 deg., and thus we get the cooling effect we want, economize good softened water and save the usual steaming cylinder of the ordinary circulation system.

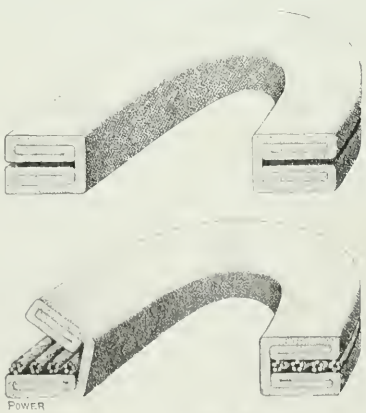
W. H. Booth.

London, England.

Using Rejected Packing

The accompanying illustrations are intended to show how a stock of asbestos gaskets which had been rejected as useless was made serviceable. The supply was bought with the intention of replacing the flat and tubular rubber gaskets that had formerly been used, the idea being to reduce the expense on this item. A section of this kind of gasket is shown below, but when they were applied every man and handhole plate leaked more or less and they had to be removed and rubber ones put in.

The chief was looking at that pile of gaskets one day when he got the right idea. He split one of the gaskets apart and wound several layers of asbestos wick packing between the layers and pressed the parts together again, a sshown in the lower illustration.



Asbestos Gasket with Lamp Wick to Give It Softness

The cushion thus created gave sufficient flexibility and elasticity to allow the hard layers of asbestos cloth to fill the indentations of the plate and ring and when they were applied the job was tight "for keeps" as the chief expressed it.

Now when the plates are removed for boiler cleaning the old layers of asbestos wick are pulled out and new ones inserted, and the gasket is liberally coated

with graphite. These gaskets may be used again and again, and can be depended upon to be tight. The expense of renewing the wick packing is hardly worth mentioning.

W. F. Meinzer.

Brooklyn, N. Y.

Engineers' Reading Club

Many engineers complain that they have not time to read the current power-plant papers, others say they cannot afford to subscribe to the magazine or paper they are most interested in, while some very foolishly believe that it is not necessary to read of the doings in up-to-date power plant work.

To overcome this objection and also to bring the men in closer personal contact, thereby promoting more congenial working conditions tending to better efficiency, the engineering department of a well-known company formed a club which meets bi-weekly for the purpose of discussing articles in engineering magazines. Each member of the club is assigned a paper or magazine and where there is much reading matter to be covered, two or more men are assigned to a paper to assist in the preparation of abstracts from articles.

These abstracts are intended to bring out the most essential features of the articles. A note relative to the author is also made. The abstracts are written on standard size sheets and after the meeting are put in the permanent file of the department where they remain available at all times.

The company makes it a practice to subscribe to many of the leading magazines, so the data are compiled at no expense to the club members and no more effort than any engineer might put forth in compiling data for his own personal use, not to mention the great advantage to be gained from the discussion.

Morgan G. Johns.

Philadelphia, Penn.

Ashes Promote Pipe Corrosion

The use of ashes as a filling for trenches wherein are laid steam pipes or water pipes, whether galvanized or black iron, cannot be too strongly condemned. Unless the pipes are thoroughly insulated from the moisture prevailing in the earth surrounding them, serious and rapid corrosion of the pipe is sure to result. This fact does not seem to be generally realized, as in many industrial plants where pipes are laid throughout the yards, the ashes are dumped into the yards directly over the pipe lines. The result is that these lines must be taken up frequently and renewed.

In one plant of which I had charge bubbles of water and sand were noticed directly above where a pipe was located. This was a return pipe and had been installed previous to my coming to the plant. After excavating the pipe we found that several holes had been eaten in the top of it. This allowed the pipe to leak, but being a return pipe, there was often a vacuum in it, especially at night, when the plant was shut down. This allowed dirt and mud to be drawn into the pipe, which with ashes were sucked through the pipe and into the receiver, and finally drawn into the feed pump, getting under the valves and holding them off their seats, completely crippling the pump, scoring the sleeves in the water end and doing other serious damage.

At the time it was not realized just what had caused the pump valves and sleeves to wear so badly. Neither was it known just how the pipe had become so badly corroded. After the new pipe was put in, it did not last more than fifteen months, and we also experienced the same trouble with the receiver and pump. When the second pipe was put in it was thoroughly isolated from the surrounding soil by being put in a box filled with sawdust. The ashes were also removed from this place and deposited at another part of the yard where there were no pipe lines.

Another instance that seems to prove that ashes and moisture combined act as a severe corrosive agent, is that related by a friend of mine. While on top of one of the boilers one day, he saw steam coming up through the covering, which consisted of about three inches of ashes on top of the usual asbestos. Investigation revealed that the steam pipe above the boiler had been leaking and allowed water to drop down on the ashes, creating a chemical lye or something which had eaten a hole through the top of the boiler plate. The inspector was called and immediately reduced the allowable pressure from 110 to 40 lb., until repairs could be made.

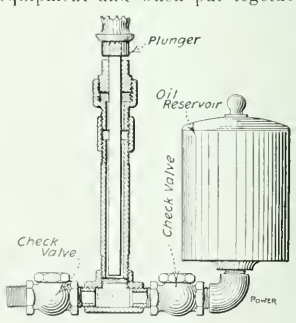
The leaking of water legs in boilers has been traced to wetting the ashes in the ashpit, and in some cases this has caused no end of patching below the grate.

A. C. Waldron.

Revere, Mass.

Home Made Force Pump Lubricator

The following fittings can be found in almost any engine-room equipment and when put together, according



Pump Lubricator Made of Fittings

to the illustration, will make a serviceable oil hand-pump that can be attached to any engine cylinder:

one ¾x3-in nipple
one ¾x¼-in reducing coupling
one ¼-in. plug
one ¾-in. coupling
one ¾x¼-in. tee
one round iron rod ¼x5-in.
four ¼-in. close nipples
one ¼-in. ell
two ¼-in. check valves
one lubricator oil reservoir
one old file handle.

The plug should have a ¼-in. hole drilled through the top and can be used as the packing gland, and the reducing coupling as the stuffing-box.

Fred L. Wagner.

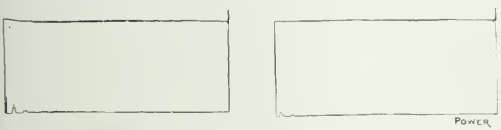
Chicago, Ill.

QUESTIONS BEFORE THE HOUSE

Pump Diagrams for Comment

In your issue of Oct. 15, you published three indicator diagrams taken from a vertical triple-expansion pumping engine 28, 54 and 80 by 60 in. with 30-in. plungers and having a capacity of 20,000,000 gal. The letter was written by John Burnes of Columbus, Ohio.

I enclose two cards taken from a cross-compound pump 20, 39 and 11½ by 16¼-in. stroke having a capacity of 3,000,000 gal. at 40 r.p.m. with 225-ft. elevation of



LOW-PRESSURE SIDE HIGH-PRESSURE SIDE

discharge. The suction lift is 14½ ft. An 80-lb. spring was used in the indicator producing the diagrams. I would like Mr. Burnes or other readers to criticise these diagrams and advise what I can do to improve the action of the pump.

Olean, N. Y. E. A. HOMER.

Interesting Boiler Experience

Referring to the article appearing under the above heading in the Nov. 5, 1912, issue of POWER and signed by Thomas Sheehan, North Adams, Mass., I beg to state that while Mr. Sheehan's article describes the difficulty encountered, it does not correctly state the real cause of the difficulty, nor how it was overcome.

The facts in the case are that the load upon the Hoosac Tunnel power plant of the Berkshire Street Ry. has been, and still is, very irregular, varying from extremely light loads to considerable overloads, the latter lasting but a few moments, then going off almost entirely.

With the boilers, which are equipped with Taylor under-feed stokers, under fire, and generating only sufficient steam to operate the exciter units, and the main units very lightly loaded, the fires are comparatively dead. When the overload comes on, an automatic valve controlled by the steam pressure instantly opens the forced-draft-fan steam supply wide, starting up the turbine-driven forced-draft fans to their highest speed, and almost immediately bringing the fires on the stokers to a state of high incandescence. This is accompanied by a very sudden drop in steam pressure.

When the load goes off, the conditions are reversed, the fires being immediately deadened by the cutting off of the air supply, and it was originally the practice of the power-plant attendants to open all the doors on the boilers which they could reach, to rapidly cool the fires by admitting cold air over the fuel.

This entire cycle imposed about as severe conditions upon the boilers in question as it was possible to obtain, and conditions which are more extreme than any now known to the writer.

As Mr. Sheehan states, tube failures were not at first encountered; but after the plant had been in operation for a time, tube failures began, and grew more and more frequent. This condition seemed to be entirely beyond analysis by any of the power-plant crew, and it was not until the manufacturers were called into consultation that it was found that the tubes in question were covered with a scale from $\frac{3}{16}$ to $\frac{1}{4}$ in. thick. The feed water from which this scale was formed came from artesian wells near the plant, and analyses of the scale showed its composition to be as follows:

	Per cent.
Silica	4.59
Oxides of iron and aluminum	2.00
Calcium sulphate	25.00
Calcium carbonate	1.30
Magnesium hydrate	67.11
Total	100.00

The silica and iron and aluminum oxides form scale only in the presence of other ingredients. The calcium sulphate precipitates out at boiler pressure and temperature and mixes with the other material, forming a hard scale which is a very poor conductor of heat. The calcium carbonate forms a bulky scale which is not very hard. The magnesium hydroxide in combination with calcium sulphate forms a hard, stony scale, but, in this case, owing to the large excess of magnesium hydroxide, the scale formed is rather soft and chalky.

What probably occurred inside the boiler with the operating conditions as experienced was as follows:

The specific gravity of the magnesium compounds being near that of the water, these compounds were held in suspense for some time, gradually settling during the light-load periods when the circulation in the boilers was not active, and, owing to the slight inclination of the front tubes, these scale-forming compounds would naturally adhere to the side of the tubes next to the fire. With the recurring variations from very light load to overload the scale above mentioned, $\frac{3}{16}$ in. or more in thickness, adhered to the tubes, and when under the overload conditions the fire was suddenly urged to extreme activity, the high temperature imposed on the outside of the tubes would cause the metal to become overheated, and the tubes to bow toward the fire, as indicated by the illustration in Mr. Sheehan's article.

If there had been a constant load of some fair size upon the boilers, and no comparatively frequent periods of considerable duration of extremely light load, it is probable that the circulation would have carried the scale-forming particles into the back sections where the circulation is comparatively inactive, and these particles would have been precipitated in the rear units, dropped into the mud drums, from which they would have been removed at intervals through the blow off. This would also have been true if the water had been of a different nature, and impurities ordinarily encountered except magnesium had been present, so that such impurities

would not have been so readily carried forward by the circulation to be left in the forward tubes during the periods of comparative inactivity.

The first care of the station operators should have been to examine the boilers internally, and determine whether their internal condition was satisfactory. The scale formed upon the tube surfaces was an excellent insulator to the passage of heat. As the boilers have since been cleaned, and treatment of the water has been instituted, the troubles referred to have disappeared.

The plant is at present operating quite satisfactorily under conditions sufficiently severe to probably make a great deal of trouble with any apparatus which is not especially adapted for handling the most extreme variations of load in the shortest possible time.

New Haven, Conn. E. S. Cooley.

The Allis-Chalmers Engine

It was with pleasure that I read the article in the issue of Sept. 17, on the new Allis-Chalmers engine. I am particularly interested because the chief features of this engine, which lead to the excellent results (so far as steam consumption is concerned), are exactly copied from the construction of the Rice & Sargent engine, which Mr. Sargent and myself designed about nineteen years ago, and which has been on the market since that time with excellent success.

I refer to the double-ported steam valves located close to the cylinder port, and the double-ported exhaust valves, partly projecting into the cylinder, but sufficiently beyond the piston travel to be out of danger of contact therewith. Also to the steam valves moved by direct lever motion in contrast to the usual wristplate motion, thereby permitting the engine to cut off as late as three-quarters of the stroke; whereas the wrist motion limits cutoff to between 0.4 and ½ stroke, while the exhaust valves are moved by a separate eccentric and coupled to the usual wrist motion.

These are the essential features of the Rice & Sargent engine, and it is gratifying that after 19 years the Allis-Chalmers Co. has adopted these points.

So far as I can ascertain from an inspection of the article, the only novel feature about the engine is the governor, and this departure from the Rice & Sargent design would hardly seem to be warranted, as the governing mechanism is more complicated than the inertia governor used by us, without being so sensitive in providing against variations in speed.

One other point which was provided for in the Rice & Sargent engine, which does not seem to have been incorporated in the Allis-Chalmers machine, so far as the drawings show, was provision for expansion of the steam cylinder without throwing it out of line, at the same time without introducing any stresses in the foundation or bedplate. I commend this point to the designers of the Allis-Chalmers company.

West Lynn, Mass. Richard H. Rice.

State Boiler Inspection

The editorial under this heading in the Dec. 3 issue was read with much interest and it brought out some very good points. There has been a large number of serious boiler explosions in the last few years and if the daily papers would show them up as Power does, the public would soon demand protective laws. But there was one statement in the editorial that I wish to take exception to. It was stated that Massachusetts and Ohio were the only states having such laws and enforcing them. Montana also has very good boiler laws and competent inspectors to see that they are enforced.

Each stationary boiler in this state has to be inspected once during each year. The inspectors are very careful and thorough in their work. I worked in one plant where they required the pressure to be reduced from 125 to 110 lb., and the boilers were not over seven years old. They also ordered the steam pipes, traps and blowoff pipes kept in good condition. I have been in Montana eight years and have not heard of a serious explosion in that time. Any man in charge of boilers who has to attend to the water must have a third-class engineers' license. To be able to take the examination he must have had at least one year's experience in firing or running steam boilers or engines. To get a first-class license an applicant must have had three years' experience.

Some engineers complain about state boiler inspection and license laws, but when a man steps into a plant which has been inspected by a competent inspector he feels safer than he would if the plant had never been inspected.

Harold J. Wilkinson.

Livingston, Mont.

Stick Phosphorus for Flue Gas Analysis

The point made by G. W. Munro in the Dec. 3 issue about washing off the sticks of phosphorus, while good, is not a thing requiring frequent performance. Taking 100-c.c. samples of free air, 100 such samples would contain about 2100 c.c. of oxygen, which would weigh 3.003 grams. This would burn with 3.879 grams of phosphorus to P_2O_3, and with 2.327 grams of phosphorus to P_2O_5 (in moist air, such as exists in a gas apparatus, the combustion product is a mixture of the two). In the first case only 1.126 c.c. of water would be necessary to convert the P_2O_3 to HPO_2; in the latter only 0.675 c.c. of water to convert the P_2O_5 to HPO_3, while the ordinary phosphorus pipette holds about 120 c.c. of water. Flue gas never carries 21 per cent. of free O_2.

As to A. H. Gill's objections, the ordinary analyst should not attempt to make his own phosphorus sticks but should buy them. The change from white to red phosphorus ("the tough leathery skin") is slow except in direct sunlight. Unless a hole be broken in the pipette the leakage of air will not be rapid enough to cause the phosphorus to melt; a crack will not do it.

If Mr. Gill has any quantitative results on the formation of ozone by moist oxidizing phosphorus, I wish he would publish them. I have never seen anything but qualitative tests showing that ozone could be formed under those conditions, and always thought that traces only were made, which were not quantitatively comparable with the inaccuracy of the various determinations arising from other sources.

This I know, that I have seen carbon monoxide reported many times when it did not exist, through the use of an old pyrogallate solution which did not absorb the oxygen, with subsequent absorption of this O_2 as CO.

Donald M. Liddell.

Elizabeth, N. J.

INQUIRIES OF GENERAL INTEREST

Variation of Water-level—Does the water stand still in a boiler when the engine is running, or does it move up and down in the glass?

E. D. P.

When the boiler steam space is small in proportion to the size of the engine cylinder, the gage-glass may show a variation in water level at every stroke of the engine.

Cylinder Trouble—Why does water in a steam cylinder cause trouble?

P. D.

If there is water in a cylinder more than sufficient to fill the clearance space at the end of the stroke, since it cannot escape after the exhaust valve closes, damage will result to the cylinder as by breaking or knocking out the cylinder head because water is nearly incompressible.

Determining Rivet Sizes and Pitch—What determines the sizes of rivets and pitch?

C. H.

The selection of rivet sizes is largely a matter of convenience and practical experience. The following are used in average good practice:

½-in. thick plate or strap	½-in. rivets
5/16-in. thick plate or strop	¾-in. rivets
⅜-in. thick plate or strap	⅞-in. rivets
7/16-in. thick plate or strap	1⅛-in. rivets
½-in. thick plate or strap	1-in. rivets

Having found the size, the pitch is so selected as to obtain a joint of highest efficiency. This must be a joint the strength of which will be the highest percentage of strength of the solid plate for a unit length of joint. "Rules Formulated by the Massachusetts Board of Boiler Rules," pages 13 to 19, furnishes a reliable method of calculating joint efficiency. To find the efficiency of a butt and double strap joint, see POWER of Dec. 31, 1912, page 985.

Cylinder Compression—What is the meaning of compression as applied to the steam-engine cylinder?

L. M.

If by the compression as applied to the cylinder is meant the compression of the steam in the cylinder, the word as usually used signifies the compression of the steam, which is left in the cylinder when the exhaust valve closes, into the clearance space by the completion of the stroke by the piston. Such compression is used to cushion the engine to absorb to some extent the momentum of the moving parts so as to change the direction of pressure upon the pin gradually and also to fill the clearance space with the denser, hotter and higher-pressure steam.

Reducing Piston Clearance—What advantage would there be in reducing the piston clearance ¼ in. on each end of the cylinder of a 20x42-in. Corliss engine, the present clearance being ⅞ in.?

M. J.

The saving effected will depend on the volume of present total clearance in the cylinder and steam passages; that is, when the piston is at the end of its stroke. The only way to reduce the clearance is by increasing the thickness of the cylinder heads inwardly or that of the piston. The improved economy would depend on the size of the load and the indicator diagram the engine can make at present. Reducing the clearance ¼ in. would neither pay for the trouble nor leave safe clearance for the adjustment of the connecting rod and the crosshead.

Least Diameter of Rope Pulley—Would a 17-in. diameter sheave be suitable for a 1-in. manila-rope drive where the rope is driven by a 12-ft. diameter flywheel pulley running at 80 r.p.m.?

A. S.

The velocity of rope, driven as proposed, would be about 3000 ft. per min., and for that speed the least diameter of sheave for 1-in. diameter manila rope should be not less than 26½ in. If made smaller, the rope would wear rapidly. For general work it is found that 36-in. diameter is the smallest size practicable for use with 1-in. manila rope for all speeds. The causes of many failures and much trouble in rope driving are due to the use of too small pulleys for the size of rope and tension carried.

Engine Out of Balance—Is an engine out of balance if, when placed on either head or crank centers with the valve stem and piston-rod packing removed and all working parts connected, the crank-pin rotates to the bottom of the crank case?

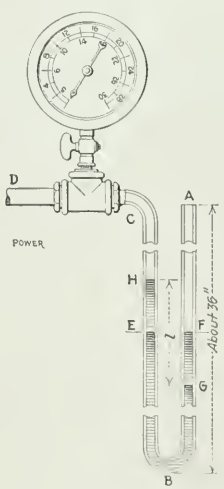
G. R. F.

To determine whether the crank settles in standing balance of the engine on account of the weight of the connecting rod, detach the crank end of the connecting rod and vibrate the flywheel by hammer strokes square against the side of the wheel. If the wheel stands balanced in every position the crank is in standing balance. The lack of balance when the rod is connected up is due to the weight of the connecting rod not being balanced in standing balance. The engine may not be in standing balance, but may be in running balance. Running balance can only be adjusted by placing different weights in different positions on the flywheel when the engine is running at its proper speed. The weighting thus required is not generally suitable for standing balance.

Testing a Vacuum Gage—What is the best way to test a vacuum gage?

H. F.

The best way to test a vacuum gage is to compare it with a glass U-tube mercury gage as indicated in the sketch. The bent tube ABC, having about ⅜-in. bore, is connected by suitable fittings to the pipe or nipple D, and the latter is connected with an air pump or condenser. The gage to be tested is placed on a tee. The U-tube should be about 36 in. over all and should be about half filled with mercury. When there is a partial vacuum made at D the atmospheric pressure acting on the surface of the mercury in the open tube AB, being greater than the pressure acting on the surface



of the mercury in the tube CB, the mercury at the original level EF will fall in AB, as to G, and rise in CB, as to H, and the difference of level between H and G as indicated by the dimension l, measured in inches, will be the "inches of vacuum" which the vacuum gage should indicate. While most manufacturers of vacuum gages are equipped with a U-tube mercury gage, they generally make comparisons with another gage, known to be correct with the U-tube gage. For testing a vacuum gage at a plant not equipped with a mercury gage, the usual practice is to compare the gage to be tested with one considered to be correct.

ENGINEERS' STUDY COURSE

Logarithms—Part II

As we learned in our last lesson, the logarithm of a number consists of two parts: an integral part and a decimal part, the integral part being called the *characteristic*, and the fractional part called the *mantissa*.

Rule 1. *The characteristic of the log of a number greater than unity is less by 1 than the number of integral places in the number and is positive.*

Thus the characteristic of the log of 48,226 is 4.

Rule 2. *The characteristic of the logarithm of a fraction or a number less than unity is greater by 1 than the number of ciphers immediately after the decimal point and is negative.*

From this rule we see, as learned in our last lesson, that the characteristics of logs of numbers below one are negative. From 1 to 9 they are 0 + a decimal fraction; 10 to 99 they are 1 + a decimal fraction; 100 to 999 they are 2 + a decimal fraction; 1000 to 9999 they are 3 + a decimal fraction, and so on. Study this paragraph, as it must be *memorized*.

$$1000 = 3$$
$$100 = 2$$
$$10 = 1$$
$$1 = 0$$
$$0.1 = \bar{1}$$
$$0.01 = \bar{2}$$
$$0.001 = \bar{3}$$

In logarithmic tables the characteristic is omitted and the mantissa only is given, usually without the decimal point before it, it being understood that it is a decimal. Most logarithmic tables, however, have a table giving the logs complete of numbers from 1 to 100 inclusive. Such a table is given in Table No. 1.

A page of the logarithmic tables of Vega are given in Table 3. They are carried to the seventh decimal place.

Use of Logarithmic Tables

To find the logarithm of a number containing one or two figures, such as

$$\log 8.5 = 0.929419$$
$$\log 0.85 = \bar{1}.929419$$
$$\log 0.085 = \bar{2}.929419$$

Referring to Table No. 1, under column "N.," find 85; the log of which is 1.929419. The mantissa for 8.5 will be the same but as the characteristic of numbers between 1 and 10 is 0 we strike out the characteristic 1 and substitute a cipher. The log of 0.85 is negative, i.e., less than zero by 1 because there is no cipher immediately after the decimal point (see rule No. 2); therefore, the characteristic of its log is negative, but the mantissa is again the same; hence it is expressed as $\bar{1}.929419$. Notice the minus sign over the characteristic. The log of 0.085 is negative, i.e., less than zero by 2; according to rule No. 2 the characteristic of the log of a decimal fraction is greater by 1 than the number of ciphers immediately following the decimal point. Here there is one cipher so the characteristic is $\bar{2}$ and the mantissa still the same.

To find a log of a number containing three significant figures. In the column headed "No." find the number. In a horizontal line with it and under the column headed "0," find the mantissa. Prefix the required characteristic.

Table No. 1

Logarithms of Numbers from 1 to 100.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342423	42	1.623249	62	1.792392	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799341	83	1.919078
4	0.602060	24	1.380211	44	1.643453	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653213	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431364	47	1.672098	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944483
9	0.954243	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954243
11	1.041393	31	1.491362	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.531479	54	1.732394	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740363	75	1.875061	95	1.977724
16	1.204120	36	1.556303	56	1.748188	76	1.880814	96	1.982271
17	1.230449	37	1.568202	57	1.755875	77	1.886491	97	1.986772
18	1.255273	38	1.579784	58	1.763428	78	1.892095	98	1.991226
19	1.278754	39	1.591065	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	2.000000

Table No. 2

No.	0	1	2	3
570	75,587	75,595	75,603	75,610
571	75,664	75,671	75,679	75,686
572	75,740	75,747	75,755	75,762
573	75,815	75,823	75,831	75,838
574	75,891	75,899	75,906	75,914

Thus, referring to the above partial table, find the log of 574.

$$\log 574 = 2.75891$$
$$\log 57.4 = 1.75891$$
$$\log 0.0574 = \bar{2}.75891$$

From what we have just learned we know why the characteristics change for the changes in value of the given number.

To find the log when the number contains four figures. In the column headed "No." find the first three figures. On a horizontal line with the figures and in the column containing the fourth figure, find the mantissa. Prefix the required characteristic. Thus

$$\log 5712 = 3.75679$$
$$\log 5.712 = 0.75679$$
$$\log 0.05712 = \bar{2}.75679$$

In the above example the first three figures are 571, the fourth is 2, so in the column headed "2" and on a line with 571, find the mantissa, 75,679. According to Rule 2 we see that the characteristic of the log of 0.05712 is 2 because there is one cipher after the decimal point. Vega's tables give logs of four-figure numbers directly.

To find the logarithm of a number containing more than four figures, we find the first four figures in the column "N." Table No. 3, and the last in the horizontal line at the top. The last four figures of the logarithm will be found where the horizontal line, correspond-

ing to the first four figures of the number meets the vertical line—corresponding to the fifth figure. The first three figures of the logarithm are in the column headed "0," and are common to all the figures in the same horizontal line. Where these are not given on the horizontal line, the previous three figures must be taken, except when the first of the last four figures is marked with a line above it, in which case the first three figures of the log are those that occupy that relative position in the next horizontal line below.

Example: Number 31,406, log 4.4970126.

Find the log of 31,328. The first four figures, 3132 are found in column "N." The last or 8 is found under 8 at the top of the table. The last four figures of the log are, according to the instructions just given, 9327. The first three figures are in the column "0" and are 495. Now we have the mantissa complete, which is 4959327. The characteristic, though not given, is seen to be 4, because the given number is over 10,000. Therefore, the log of 31,328 is 4.4959327.

To find the log of 31,333. Here the last four figures of the mantissa are 0020 and the first cipher is marked with a line, thus $\bar{0}$; hence they are to be combined with 496, which gives 4960020 as the mantissa, the characteristic being 4. Therefore, the log of 31,333 is 4.4960020. Suppose we wanted to find the log of 31,333.73; the difference between the logs of the two whole numbers of five figures each, between which the given number lies, must be multiplied by the decimal fraction and the product added to the log of the smaller whole number. Taking the number given, 31,333.73. This lies between 31,333 and 31,334, the logs of which differ by

$$0.158 - 0020 = 138$$

We multiply

$$138 \times 0.73 = 101$$

Notice that the decimal part of the product is rejected and the last figure of the integer part is increased by 1 when the rejected part is greater than 0.5.

Adding 101 to the log of 31,333 we have

$$4.4960020 + 101 = 4.4960121$$

for the log of 31,333.73. To facilitate this multiplication nearly all logarithmic tables contain small additional tables in the column headed "P.P." (proportional parts), Table 3, which for each of the differences of the numbers on that page gives the several tenths from which the hundredths, thousandths, etc., may be easily found.

In our last example, under the table headed "138," in column "P.P.," we get

For 0.7..	96 6
For 0.03.	4.14
	100.74

We reject the decimal fraction as before. We also moved the decimal point over one place to the left in the number 14.1 to correspond with the two decimal places in the number 0.03.

Given a logarithm, required the corresponding number. In the table, find the first three figures of the given log. Next find the remaining four figures in some one of the columns headed "0," "1," "2," "3," etc. Having found the log in the table, follow the horizontal line on which it is located toward the left, and find in column "N" the first figures of the number and prefix these to the figure found at the top of the column in which the log was found.

Given log 4.4980071, to find the corresponding number. The first three figures of the fractional part of the log appear in column "0," and the last four in column "8," but in the next horizontal line above, because in this example $\bar{0}$ occurs, as was explained about numbers with minus signs over them. The number corresponding to the log is therefore found to be 31,478.

For another example, suppose the log to be 4.4976414. We find that this log lies between those for 31,451 and

Table No. 3.

48

N.	0	1	2	3	4	5	6	7	8	9	P. P.
3100	491 3617	3757	3897	4037	4177	4317	4457	4597	4738	4878	
01	5018	5158	5298	5438	5578	5718	5858	5998	6138	6278	
02	6418	6558	6698	6838	6978	7118	7258	7398	7538	7678	
03	7818	7958	8098	8238	8378	8517	8657	8797	8937	9077	141
04	9217	9357	9497	9637	9777	9917	0057	0196	0336	0476	1 14.1
05	492 0616	0756	0896	1036	1175	1315	1455	1595	1735	1875	2 28.2
06	2015	2154	2294	2434	2574	2714	2853	2993	3133	3273	3 42.3
07	3413	3552	3692	3832	3972	4111	4251	4391	4531	4670	4 56.4
08	4810	4950	5090	5229	5369	5509	5648	5788	5928	6068	5 70.5
09	6207	6347	6487	6626	6766	6906	7045	7185	7325	7464	6 84.6
3110	492 7604	7744	7883	8023	8162	8302	8442	8581	8721	8861	7 98.7
11	9000	9140	9279	9419	9558	9698	9838	9977	0117	0256	8 112.8
12	493 0396	0535	0675	0815	0954	1094	1233	1373	1512	1652	9 126.9
13	1791	1931	2070	2210	2349	2489	2628	2768	2907	3047	
14	3186	3326	3465	3604	3744	3883	4023	4162	4302	4441	
15	4581	4720	4859	4999	5138	5278	5417	5556	5696	5835	140
16	5974	6114	6253	6393	6532	6671	6811	6950	7089	7229	1 14.0
17	7368	7507	7647	7786	7925	8065	8204	8343	8483	8622	2 28.0
18	8761	8900	9040	9179	9318	9457	9597	9736	9875	0015	3 42.0
19	494 0154	0293	0432	0571	0711	0850	0989	1128	1268	1407	4 56.0
3120	494 1546	1685	1824	1964	2103	2242	2381	2520	2659	2799	5 70.0
21	2938	3077	3216	3355	3494	3633	3773	3912	4051	4190	6 84.0
22	4329	4468	4607	4746	4885	5024	5164	5303	5442	5581	7 98.0
23	5720	5859	5998	6137	6276	6415	6554	6693	6832	6971	8 112.0
24	7110	7249	7388	7527	7666	7805	7944	8083	8222	8361	9 126.0
25	8500	8639	8778	8917	9056	9195	9334	9473	9612	9752	
26	9890	0029	0168	0307	0445	0584	0723	0862	1001	1140	
27	495 1279	1418	1557	1695	1834	1973	2112	2251	2390	2529	
28	2667	2806	2945	3084	3223	3362	3500	3639	3778	3917	139
29	4056	4194	4333	4472	4611	4750	4888	5027	5166	5305	1 13.9
3130	495 5443	5582	5721	5860	5998	6137	6276	6415	6553	6692	2 27.8
31	6831	6969	7108	7247	7385	7524	7663	7802	7940	8079	3 41.7
32	8218	8356	8495	8634	8772	8911	9049	9188	9327	9465	4 55.6
33	9604	9743	9881	0020	0158	0297	0436	0574	0713	0851	5 69.5
34	496 0990	1128	1267	1406	1544	1683	1821	1960	2098	2237	6 83.4
35	2375	2514	2653	2791	2930	3068	3207	3345	3484	3622	7 97.3
36	3761	3899	4038	4176	4314	4453	4591	4730	4868	5007	8 111.2
37	5145	5284	5422	5560	5699	5837	5976	6114	6253	6391	9 125.1
38	6529	6668	6806	6945	7083	7221	7360	7498	7636	7775	
39	7913	8052	8190	8328	8467	8605	8743	8882	9020	9158	
3140	496 9296	9435	9573	9711	9850	9988	0126	0265	0403	0541	138
41	497 0679	0818	0956	1094	1232	1371	1509	1647	1785	1924	1 13.8
42	2062	2200	2338	2476	2615	2753	2891	3029	3167	3306	2 27.6
43	3444	3582	3720	3858	3996	4135	4273	4411	4549	4687	3 41.4
44	4825	4964	5102	5240	5378	5516	5654	5792	5930	6068	4 55.2
45	6206	6345	6483	6621	6759	6897	7035	7173	7311	7449	5 69.0
46	7587	7725	7863	8001	8139	8277	8415	8553	8691	8829	6 82.8
47	8967	9105	9243	9381	9519	9657	9795	9933	0071	0209	7 96.6
48	498 0347	0485	0623	0761	0899	1037	1175	1313	1451	1589	8 110.4
49	1727	1865	2002	2140	2278	2416	2554	2692	2830	2968	9 124.2
3150	498 3106	3243	3381	3519	3657	3795	3933	4071	4208	4346	
N.	0	1	2	3	4	5	6	7	8	9	P. P.

31,452 and that the difference between log 31,451 and the given log is

$$6411 - 6345 = 69$$

Now in the table headed "139" in the column "P.P." of proportional parts, find that 5 gives a difference of 69; therefore the corresponding number to log 4.4976411 is 31,454.5.

Suppose we are given the log 1.4956413. The nearest log to this one is 1.4956415, to which corresponds the number 31,307. The difference between it and the next greater log 1.4956553, is

$$6553 - 6415 = 138$$

while the difference between it and the given log is

$$6413 - 6415 = 28$$

The figures following the first five places are found from the table of proportional parts, headed "138." Take from it the next figure 2, corresponding to 27.6, which

is next inferior to 28; subtracting 27.6 from 28 gives 0.4. Take this 10 times, which gives 4, which corresponds to 0; taking it 100-fold, which is 40, which is opposite to the next inferior number, which is also 27.6 and being opposite 2, this number (2) becomes the eighth figure of the number. Now the difference between 40 and 27.6, which is 12.4, is increased tenfold, giving 124 which, being opposite 9, shows that 9 is the last figure of the number, 313,072,029. Since the log has an index or characteristic of 4, the decimal point (see rule 1) must be put after the fifth figure. The number now becomes 31,307.2029.

ANSWERS TO LAST WEEK'S QUESTIONS

(1) To quickly and conveniently find the roots and powers of numbers.

(2) 10.

(3) Numbers between 1 and 10; between 10 and 100; between 100 and 1000; between 1000 and 10,000; between 10,000 and 100,000.

(4) (a) Add the logs of the multiplicand and multiplier to find the log of the product. (b) Subtract the log of the divisor from the log of the dividend to find the log of the quotient. (c) Multiply the log of the number by the exponent to find the log of the required power. (d) Divide the log of the given number by the index of the root (2 for the square root, 3 for the cube root, etc.), to find the log of the required root.

A Record in Plant Construction

An instance of rapid power-plant construction has recently come to light in connection with the extension to the Jordan steam station of the Utah Light & Ry. Co., at Salt Lake City, by Westinghouse, Church, Kerr & Co., of New York.

The original station was designed and built by the same engineers in 1910 and consisted of an 8500-kw. single-unit steam turbine installation intended to supplement the several hydro-electric plants of the company and also to form a nucleus for such steam-generating equipment as might be required later.

The new work practically duplicates the former plant and comprises in general a brick and steel building 100x 60 ft., the walls resting on a pile concrete mattress consisting of 36-ft. piles overlaid with about 3 ft. of concrete. The boiler equipment consists of Stirling boilers fitted with Roney stokers and served by a 225-ft. radial brick stack. The turbine equipment consists of one Westinghouse-Parsons unit of 8500 kw. capacity delivering 60-cycle, three-phase current at 4400 volts. Thus the total capacity of the plant (original and extension) is 17,000 kw.

The rapidity with which the work was carried on may be seen from the following: On Mar. 27, 1912, authorization was received to design the extension. Five days later sufficient progress had been made so that the main unit, the boilers, condenser, stack, heater, stokers and piles had been purchased. On Apr. 6 excavation was begun and two weeks later the first piles were driven. On Aug. 26—152 days after authorization—the plant was put under commercial test.

The strength and brittleness of steel plates as affected by various boiler waters are being investigated at the engineering-experiment station of the University of Illinois.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Water goes over the spillway of the Gatun dam on the Panama Canal at the rate of 16,000 cu.ft. per sec. This spillway is about 70 ft. high—"Leslie's Weekly." Our little spillway is only 10 in. high, but think of— Well, you're reading it, and our modesty forbids our saying any more.

Our Uncle Sam, as head of his large and growing family, has tucked away in his jeans the tidy little sum of $3,350,727,580. Including you and me, the family is 96,496,000 strong. Divided up equally, each has $34.72 to his credit. See you tonight after the whistle blows and we'll hot-foot it over to Washington and get ours before the crowd is on.

Rechid Pasha, made timorous by Bulgarian victories, has goulashed his chances as an efficiency engineer, and wants to go home. Don't feel so wretched, Rechid. Pshaw, pasha, buck up; you know by this time that the Bulgarian hug has put the Turkey trot in the scrap heap.

If you were an editor, and sweated over the "Inquiries" page in an endeavor to be the correct answer to the sum of all human knowledge, and spent two whole days answering "Old Subscriber's" inquiries, and then found you had overlooked his postscript telling you to stop his paper as his fireman took it and he'd read his, and— Talk about reciprocal relations, old chap; you can jolly well believe this blighter is the absolute limit, eh what?

The alleged report of the formation of a "water-power trust" has apparently incited the glue makers to go and do likewise. If the glue people once get together, they'll stick all right. Oh, Tessie, wouldn't this be just too perfectly mucilaginous for anything?

Cheers for the New England Society, says "Leslie's Weekly," for wishing J. Pierpont Morgan and Joseph H. Choate "good health and many happy years to come." Our field keeps us out of the financial and legal zones, but here's three cheers and a tiger for anyone who will say a good word for his fellows.

Great have been the researches of the scientists! Based on calculation of radioactive phenomena, that dear old lady Mother Earth has reached her 711 millionth birthday, and is still going strong. Over in Sussex, England, a brace of high foreheads have unearthed the oldest known skull. Here's your opportunity. Where is the thickest known skull? No beans-in-the-jar guesswork. A handsomely bound copy of "Thick Craniums I Have Known" will be given the first discoverer. This contest is limited to "Power" subscribers.

A "scrap" expert has been added to the navy personnel. At first thought, this title may suggest its appropriateness in a body whose main duty is to scrap a heap in wartime. But this expert has been set to reclaiming materials thrown into the scrap heap, as the government hopes to save considerable through this new economy. This expert has a fighting chance to win out.

Some "food for thought" has been served us in a pamphlet written by a prominent banker entitled "Who Shall Control Our Financial Destiny?" Friend banker said the question has three possibilities. We took it home, showed it to friend wife, and she settled the control right off the handle. She also leaves the possibilities to the future; has all she can do to feed and clothe our "realities." Truly, the hand that agitates the cradle dominates!

Mexican rebels have been shooting down the power-transmission lines and cutting off the light service in Mexico City. A little ginger is an incentive to good results, but the red pepper in the chile con carne is overdoing the thing in Mexico apparently.

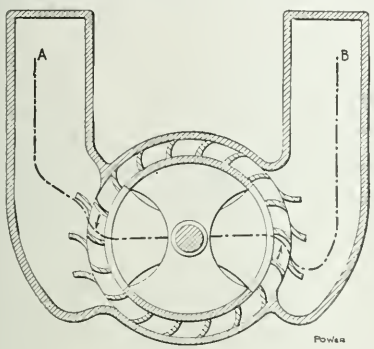
It beats all, the blows aimed at the privileges of us working people. Along comes the U. S. Public Health Service and tells us to cut out the fingerbowl; it's full of germs! Next thing, brother, we will be told to avoid the manicure—and some of them are so darn attractive it is that we should worry!

We wish we had—for this column only—the exclusive services of that newspaper reporter who thus sums up the reason for a large fire in a Western city: "The fire had its origin from an electric wire on a hot journal of one of the immense boilers, causing an explosion of the boilers." Then all at once, the sun went down and the stars came out!

A Gas Propelled Water Turbine

One manifestation of the striving for the application of the internal combustion principle to a motor of the turbine type is the proposition illustrated in the accompanying sketch reproduced from our English contemporary, *Engineering*, submitted by James Dunlop, of Glasgow.

The turbine casings and the explosion chambers *A* and *C* are filled with water until it reaches to about half the



A Gas-propelled Water Turbine

height of each chamber. By alternate explosions in each chamber the water is caused to operate through the turbine and in doing so to maintain continuous rotation of the turbine wheel. The dotted lines indicate the course of the water and the direction of the driving reactions. For a given number of impulses, any desired speed of revolution may be obtained by varying the diameter of the wheels or the arc of circumference made effective. For high speeds entrance would be around the whole circumference of one wheel and exit around the circumference of a similar wheel. Axial-flow wheels might be similarly arranged.

The Myriawatt

At a joint meeting of the Standards Committee of the American Institute of Electrical Engineers, and of a committee specially appointed for the conference by the American Society of Mechanical Engineers, on Dec. 13, 1912, at the Engineering Societies Building, New York, the following resolutions were unanimously adopted, and have been duly reported to the governing boards of the two above mentioned engineering societies:

WHEREAS, the "myrowatt" or "myriawatt" was suggested by H. G. Stott as a convenient unit of power only 2 per cent. larger than the most recently determined values of the "boiler horsepower," and,

WHEREAS, a paper* setting forth the advantages of the use of the "myriawatt" as a unit of power in dealing with the performance of steam boilers, steam engines, gas engines, steam and water turbines was read by Messrs. H. G. Stott and Haylett O'Neill before the annual convention in Boston of the American Institute of Electrical Engineers in June, 1912, was discussed, and was published in the *Proceedings* of the institute, and

WHEREAS, the American Society of Mechanical Engineers has appointed a special committee to confer with the Standards Committee of the American Institute of Electrical Engineers upon this unit, as presented in the said paper, be it

RESOLVED, (1) that the committees in joint session recommend to their respective societies the use of the "myriawatt" as unit of thermal or mechanical power, as indicated in the above mentioned paper.

(2) That the two committees also jointly recommend to their respective societies the exclusive use of the "myriawatt" in connection with boilers, producers, turbines and engines and discontinue the use of the term "boiler-horsepower."

(3) That C. O. Mailloux as representing H. G. Stott on the special committee on "Prime Movers" recently appointed by the International Electrotechnical Commission, which committee is scheduled to meet at Zurich, Switzerland, on Jan. 18, 1913, shall be and hereby is requested to bring these joint resolutions formally to the notice of that body in Zurich.

(4) That the two committees jointly recommend that in writings and publications the "myriawatt" and "myriawatt-hour" be abbreviated to mw. and mw.-hr. in conformity with the existing abbreviations kw. and kw.-hr. for kilowatt and kilowatt-hour respectively.

The above resolutions are important for two reasons, namely:

(1) Because this is the first piece of joint standardization work that has been accomplished between two of the national sister engineering societies having their homes in the Engineering Societies Building, of New York City, and it is to be hoped that this may be the starting point for much good joint action of a similar nature between all of the national engineering societies, and (2) The resolutions indicate and recommend a simple and satisfactory method of rating the input and output of turbo-generators, in terms of one and the same unit—the international watt. Instead of rating the output of a turbo-generator in kilowatts, and the input in boiler-horsepower or other heat units as at present, it becomes very convenient to rate the electro output in kilowatts, and the steam input in myriawatts, because the myriawatt is approximately the same as the boiler-horsepower while it is also exactly 10 kw. By this means the long existing incongruity of stating the input and output in different and disconnected units of power will be eliminated.

*Reprinted in Power, Aug. 27, 1912, p. 289.

Largest Mine Hoist in the World

What is thought to be the largest mine hoist in the world was recently ordered from the Nordberg Manufacturing Co., Milwaukee, Wis., for the Inverness Ry. & Coal Co.'s mine, at Inverness, Cape Breton Island. It is of the Nordberg-Corliss duplex, double-drum type. The cylinders are 34 and 34 by 72 in., and the hoist has two drums, each equipped with Nordberg axial clutch and post brake, enabling independent operation of either drum. The brakes, clutches, reverse and throttles will be operated by an auxiliary engine.

The hoist will pull a 11,000-lb. load up a 10,000-ft. incline, which is 16 deg. at the surface and 35 deg. at the bottom. From the standpoint of rope stress and length of cable, this hoist is thought to be the largest ever

constructed. Hoists with larger cylinders have been built for the copper-mining business, notably the two Nordberg hoists at the Tamarack Mines in Calumet, Mich.

Locomotive Boiler Accidents

In the first annual report of the Chief Inspector of Locomotive Boilers to the Interstate Commerce Commission, John F. Ensign gives an interesting review of the work carried on during the fiscal year ending June 30, 1912, and the more important requirements of the rules adopted by the commission. A tabular list of the accidents resulting from failure of locomotive boilers and their appurtenances during the year is included and also a number of plates illustrating locomotive-boiler explosions. A classification of the accidents, giving the number of deaths and injuries resulting, appears in the accompanying table.

CLASSIFICATION OF ACCIDENTS AND RESULTING DEATHS AND INJURIES

Nature or Cause of Accidents	Number of Accidents	Killed	Injured
Shell explosion	3	27	41
Crown sheet failures due to low water (no contributory cause found)	69	35	129
Crown sheet failures due to low water, where contributing defects were found	25	19	39
Defective blowoff cocks	23	2	22
Defective washout plugs	11	2	14
Burst water glasses	165	1	168
Burst flues	56	1	62
Steam leaks obscuring engineer's view	1	1	
Defective steam pipe joints	7	2	7
Defective boiler checks	11	1	11
Burst lubricator glasses	49		49
Defective squirt hose and connections	243		245
Defective injector steam pipes	31		38
Arch tube failures	18		23
Injector failures	46		47
Defective water-glass cocks and appurtenances	8		8
Flue plug failures	7		8
Defective studs	12		14
Defective lubricators	11		12
Defective blower pipes	9		10
Defective staybolts	9		11
Defective dome caps	2		2
Defective draft pipe and brackets	2		3
Burst water bars	3		4
Defective arch studs	2		3
Defective threaded plug (flue sheet)	1		1
Defective ash-pan blowers	3		3
Defective cap on branch pipe	1		1
Defective valves	5		5
Defective mud ring	1		1
Defective patch bolt	1		1
Defective whistle elbow	1		1
Defective arch tube plugs	2		4
Defective blower throttle bonnets	2		2
Burst steam pipe in smoke arch	1		1
Defective diaphragm plate	1		1
Defective fusible plug	1		1
Defective flue pockets	3		4
Defective gage cocks	4		4
Defective heater pipes	2		2
Defective superheater pipe	1		1
Defective gasket handhole plate	1		1
Defective flue sheet	2		2
Total	856	91	1005

Government Coal Purchases under Specifications

In Bulletin 41 of the Bureau of Mines, George S. Pope explains in general terms the methods that the Government has found most satisfactory for the purchase of a large part of its coal supply, including the consideration of bids, the awarding of contracts, and the analyzing of samples on which the price corrections are based.

For the information of prospective bidders on Government contracts, a list of the coal contracts enforced during the fiscal year ended June 30, 1911, is furnished. General averages of the analyses during the fiscal years, 1908 to 1910, inclusive, are tabulated for the various sizes of anthracite, and also for the several kinds of bituminous coal purchased for Government use; and the results for the fiscal year ended June 30, 1910, are shown in detail by months.

Government contracts are based either on a standard heating value for coal "as received" and a standard percentage of ash "dry coal" or on an ash "dry coal" standard only. The former type of contract is always used for bituminous coal, and is applicable to anthracite as well. The latter type is applicable to anthracite only, but the double standard is becoming more generally used. The specifications for the fiscal year, 1912-13, will differ from the specifications used in preceding years in that the heating value will be expressed on the "dry-coal" basis, provisions being made for variations in the heating value of delivered coal by the establishment of a moisture standard for each contract. They appear in full in Technical Paper 15 of the Bureau of Mines. In the present bulletin the British thermal unit and ash standards are outlined. A chapter on the fuel-inspection laboratory of the Bureau of Mines and methods employed, by Joseph D. Davis, is also included in the Bulletin.

SOCIETY NOTES

Registration on Jan. 7 in the N. A. S. E. evening class at the Lane Technical High School, Chicago, was heavy, 84 being enrolled. Because of this, three divisions were formed, of about 24 members each, to take the same work but to meet on separate nights. This class is the result of an offer by Dr. William Bogan, principal of the school, to furnish a room and an instructor for an engineers' class if sufficient registration were received. The work to be taken up includes power-plant chemistry and the testing of power-plant equipment.

PERSONALS

J. C. Ross has taken charge of the drying department of the B. F. Sturtevant Co., Hyde Park, Mass.

George D. B. Van Tassel has left the Westinghouse Machine Co. to accept a position with the Power Specialty Co., Chicago.

Richard Cary has been appointed sales manager of the lubricant department of the International Acheson Graphite Co., Niagara Falls, N. Y.

H. C. Barber, who was assistant chief engineer of the municipal hydro-electric system in Hamilton, Ont., has been appointed assistant manager of the Toronto Hydro-Electric System.

Charles Merritt has resigned the position as chief engineer of the Phoenix Furniture Co., with which he has been for 21 years, to take charge of the Grand Rapids Municipal pumping and electric light station, in the place of W. M. Gormley, who resigns to return to the American Seating Company.

William Naylor, to celebrate his eightieth birthday, was tendered a complimentary dinner at the Tavern, Chicago, on Jan. 4. Mr. Naylor is highly esteemed by a host of acquaintances and friends and this dinner was the occasion of congratulating him on having rounded out fourscore useful years. He was the engineer of the Marshall Field plant when this now great mercantile business was in its infancy.

C. M. Garland, formerly with the R. D. Wood Co., at one time a member of the faculty of the University of Illinois, is now associated with Woodmansee, Davidson & Sessions, consulting engineers, Chicago, as a combustion engineer. Mr. Garland has had extensive experience in theoretical and practical combustion work during the past ten years, and has specialized in the gasification of fuels and the application of producer and water gas to industrial and power requirements.

CORRECTION—In the article on "Flat Surface Supported by Stay-bolts," in the Dec. 24 issue, the author's name should have been A. J. Loppin instead of A. J. Toppin; also the charts, Figs. 6 and 7, should have been interchanged.

The Wheeler Condenser & Engineering Co., Carteret, N. J., announces that it has acquired the American license to build turbo air pumps of the type manufactured in Europe by the Allgemeine Electricitaets Gesellschaft. This air pump is of the rotary water jet type, for motor or steam turbine drive, air being removed from the condenser by ejector action of a series of small water jets and also by positive entrapment of air between successive small slugs of water. A number of these pumps are now under construction at the works of the Wheeler company.

POWER

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Mental Indigestion

NOT long since, a young man who had had some experience around small steam plants applied to the chief engineer of a large mill in Southern New England for a position as oiler. His object was to get in touch with larger engines and their auxiliaries, hoping some day (so he said) to be able to take charge of a plant. He was hired. One day he asked the chief what books or mechanical publications he would advise him to take.

"Young man," said the chief, "you might take all or any of the books that are published and they would be of no benefit to you unless you read them and think about what you read. My advice to you is to get an engineers' catechism, and subscribe for the best paper published that is devoted to the interests of this profession, and read them and think."

The mere possession of any number of books and papers will not benefit a man or make an engineer of him, nor cause him to advance, no matter what they may contain. He must read them, digest them. Food taken into the stomach is of benefit to the system only when it is digested. Good seed sown on fertile soil will produce results, but the best seed sown on a gravel heap will produce nothing. The best medicine known to the medical profession will have no beneficial effect on the patient if allowed to remain in the bottle. Books and papers are of no value if allowed to remain unopened.

Ten years ago a drummer called in to see the chief engineer of a plant, and while waiting for the chief to make his appearance got into conversation with the oiler, who told the drummer that they had been using his firm's goods for eight years to his knowledge, for he had been oiling there that length of time and he knew.

Upon being asked what mechanical papers he read, he replied that he did not "go much" on mechanical papers, and when he got time to read he generally got hold of story magazines or something that was interesting as he had been in the business so long that reading mechanical papers was like reading a rehash of old chestnuts. That man is still an oiler after eighteen years.

A man who had run an engine in a good sized factory for over two years without having any serious mishap, made application for membership in an association of engineers. One of the investigating committee on his application called on him at his engine room, and among other things noticed several numbers of a technical journal still in the wrappers on top of a closet. This same man was asked in his examination, which end of a boiler feed pump should have the larger area of piston, and he replied that "he never noticed." On being asked what the object was in putting lap on a valve, he replied that he did not know that it had any lap.

Another applicant was asked in his examination to describe how the governor on his engine performed its function of regulating the speed and replied: "By the balls flying 'round." He knew they flew 'round, but there it ended. The same man frankly said he would send for a machinist to set his eccentric if it should ever happen to slip as he would not know how to set it right.

Surely in these days with books, papers, societies and schools within the means and easy access of any one possessing the desire to learn there is no excuse for such ignorance. Such men should either make good or make room. A man is apt to progress as far as he thinks.

The man who never noticed which end of his boiler feed pump had the largest piston certainly never overworked his "think tank" regarding the construction or operation of pumps, nor could the man who did not know his valve had any lap ever have done much thinking about using steam expansively.

Do not be satisfied just to do a thing; think why you do it. Ask yourself questions, mentally and try to find the answer. Do not be like a trained dog that jumps over a chair at the word of command, without knowing why he does it. If you are asked to open or shut a certain valve, do it, and then ask yourself why? What effect did it have when I closed that valve? Think out the answer.

You are a young man and there is no excuse for you to remain an oiler if you read and think.

[*Contributed by H. R. Low, Moosup, Conn.*]

Test of Lentz Engine

SYNOPSIS—A simple 15x21-in. engine with steam at 148 lb. pressure, superheated about 50 deg. and exhausting against atmospheric pressure, runs on 19.2 lb. of steam per indicated horsepower-hour.

When a third of a century ago the leading steam engineers of America, acting as the committee on tests at the Centennial Exposition, undertook to estimate the amount of steam required for a horsepower in order to apply that unit of capacity to the steam boiler, they decided upon 30 lb. per hour, and that was doubtless a very good performance for the four-valve noncondensing engine of that period. Recently engineers and engine builders have been talking about performances below 20 lb. for noncondensing engines, and about a half of that quantity for compound-condensing units with a high degree of superheat. It is interesting to have the authority of such engineers as Robert W. Hunt & Co., of Chicago, for such figures. We have had the privilege of reviewing a detailed report made by the engineers of that company of tests carried out by themselves at the Thorp Street plant of the People's Gas Light & Coke Co., of Chicago, upon Lentz engines built by the Erie City Iron Works.

These engines were installed some two years ago, and are directly connected to blowers used for handling the gas. Front and rear views of the installation, comprising both single-cylinder and compound engines, are reproduced in Figs. 1 and 3 respectively.

On Apr. 24, 1911, engineers from the office of R. W. Hunt & Co. ran a three hours' test upon one of the

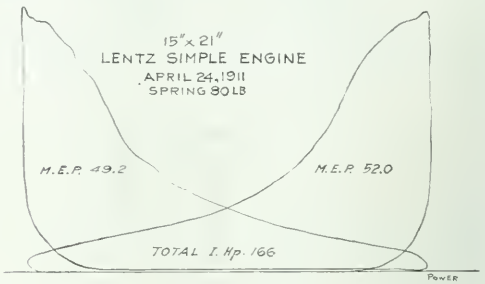


FIG. 2. DIAGRAMS FROM LENTZ ENGINE

simple engines. This developed an indicated horsepower with 19.2 lb. of steam per hp.-hr. The steam pressure at the engine ranged between 132 and 153 lb., averaging 147.6 lb. with an average superheat of 49.7 deg. F. The back pressure was that due to the atmosphere. The pro-

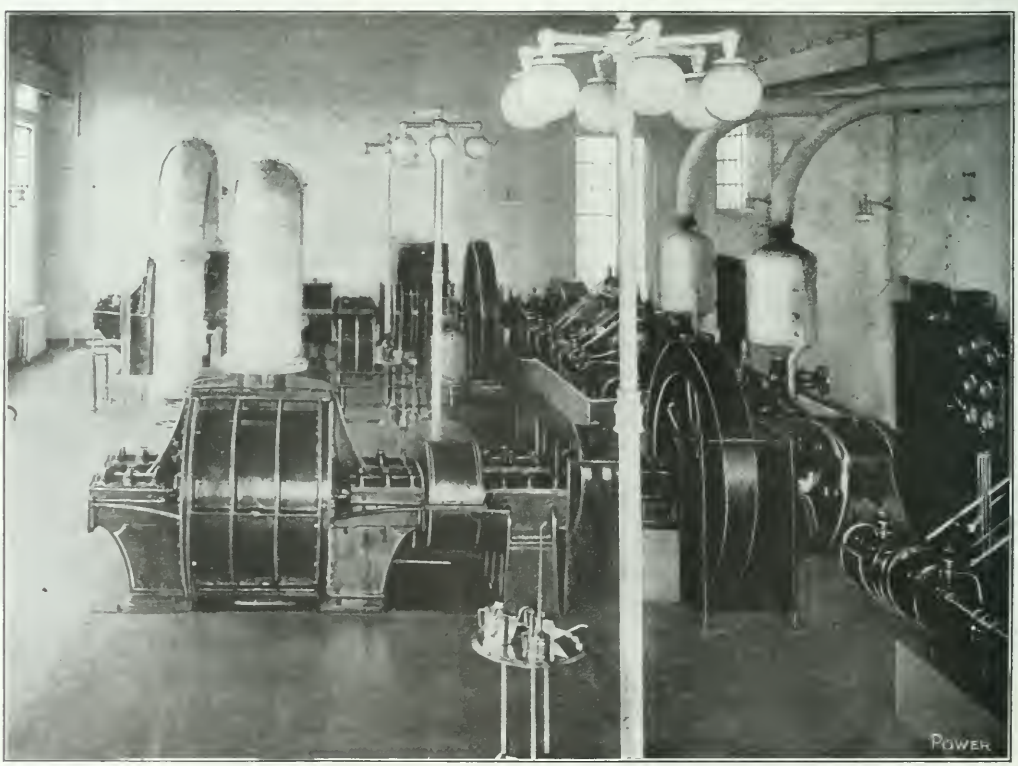


FIG. 1. FRONT VIEW OF LENTZ ENGINES IN THORP ST. STATION, PEOPLE'S GAS LIGHT & COKE CO., CHICAGO

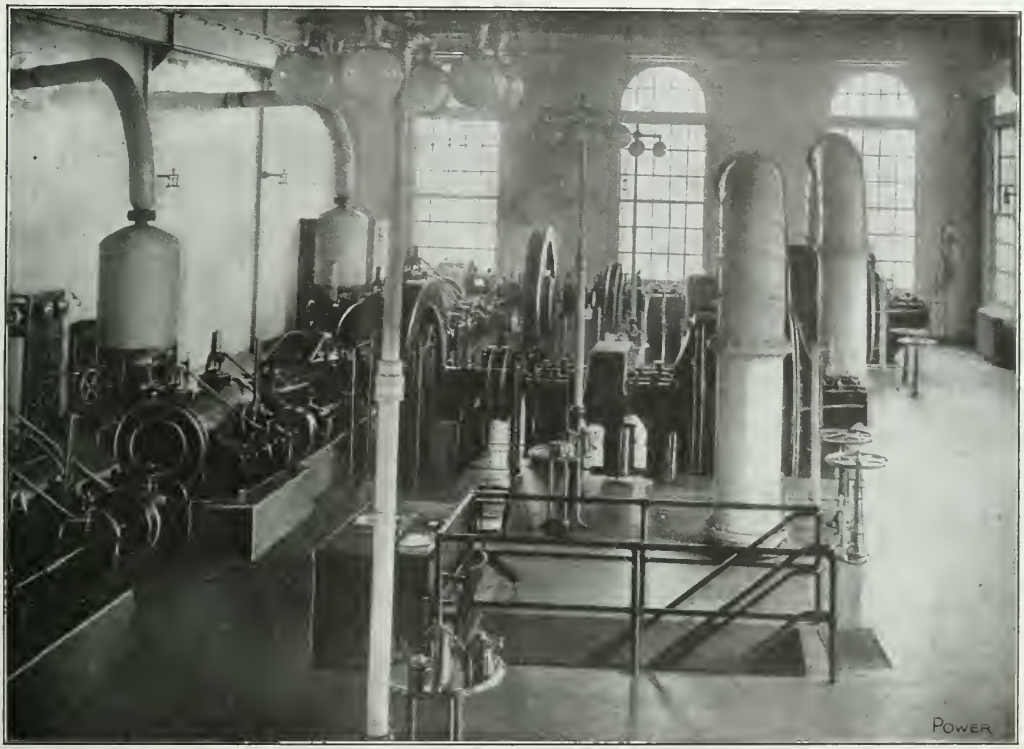


Fig. 3. Rear View of Lentz Engines in Thorp St. Station, People's Gas Light & Coke Co., Chicago

duction of a horsepower-hour under these conditions with 19.2 lb. of steam means a Rankine efficiency of over 73 per cent. and a thermal efficiency of 12.6 per cent., crediting the engine with the heat which could be taken up by the feed water at the temperature of the engine's exhaust.

The engine, which is 15x21 in., ran at 175 r.p.m. and developed on an average of 164.1 hp. during the three hours of the test. The diagram shown in Fig. 2 was taken about the middle of the test.

Dundee's New Engineering Laboratories

The new engineering laboratories at University College, Dundee, are now in use, though they have not been formally opened, says *Canadian Engineer*. The block is two stories in height. On the ground flood there are a hydraulic laboratory, small lecture room, library, photographic rooms, and engines and generating plant. On the second floor are accommodated the principal lecture room, the drawing offices, the staff rooms, the workshop, and the stress and cement-testing laboratories. Water is supplied to the hydraulic laboratory from a tank at the top of a tower, about 60 ft. above floor level, through an 8-in. main, and is returned to the tank by a motor-driven centrifugal pump which lifts 475 gal. per min.

The heat engine laboratory is divided into an engine room proper and a boiler and producer house, and the engine plant consists of a horizontal tandem-compound engine, with drop and Corliss valves and surface condensers, capable of developing 150 b.hp. at 100 r.p.m. There are also a Babcock & Wilcox boiler with an auxiliary electrically driven feed pump and economizer, the boiler being fitted with a separately fired superheater, and working up to 250 lb. per sq.in.; a 30-hp. gas engine with suction gas producer; a motor-car engine with appliances for quantitative measurements of its power and heat efficiencies, and a 50-ton testing machine.

The Micro Indicator

With increasing speed it became necessary to restrict the movements of the pencil lever and the paper drum of the indicator so as to make smaller diagrams. Some makers of indicators furnish small drums for high-speed work. This means of avoiding distortion due to inertia has been carried to a limit in the micro-indicator invented by a German by the name of O. Mader. This instrument traces on smoked glass, a minute diagram which is magnified 40 diameters by means of a microscope for measurement and analysis, or may be reproduced upon an enlarged scale photographically, or by means of a special reflecting and magnifying device. It is said that the instrument may be used upon internal combustion engines running at a speed as high as 3000 revolutions per minute.

Engineering Progress in U. S. Navy*

SYNOPSIS—Improvements in turbine and engine installations, the more important resulting from higher steam pressure, change in design of frame, reduction of clearance in cylinders, shorter steam ports, increased ratio of expansion of steam and the adoption of forced lubrication.

⁂

Turbine Changes to Produce Increased Economy

The Parsons turbine as it exists in the Navy vessels today is, with very few exceptions, the same as the turbines of this type which were fitted in the initial turbine vessel, the "Chester." The only improvements which have been made consist of changes in blade angles, particularly in the low-pressure stages, an increase in the number of rows of blades in these same stages, and the fitting of nozzles for the admission of auxiliary exhaust steam at several different locations along the steam path.

With the impulse turbine the advance over the original naval turbines of this type in the "Salem" has been rapid.

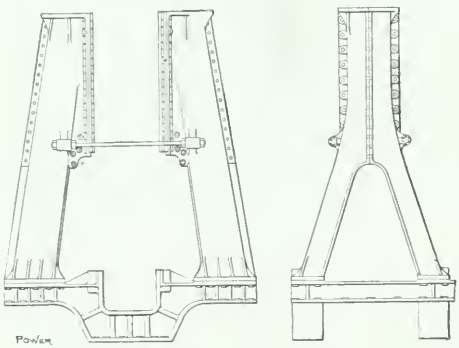


Fig. 1. Older Type of Framing Which Gave Trouble

The number of stages has been very much increased, both in battleship and in destroyer turbines, a drum construction has been adopted for the lower-pressure stages, steam balance for propeller thrust has been provided, cruising nozzles for low fractional powers have been fitted, and nozzles for utilization of auxiliary exhaust are now supplied as in the Parsons turbines.

That these changes in turbines of the impulse type have been accompanied by increase in economy has been thoroughly demonstrated by experience with the machinery of the destroyers, the economy of the impulse turbine showing up nearly, if not fully, as good as that of the reaction type. No opportunity has as yet been offered to obtain a measure of this economy increase with the battleship types of impulse turbine, nor will such opportunity occur until the "Nevada" is ready for trial.

Improvements in Reciprocating Engines

The steps taken in pursuit of the above object are:

1. Increase in steam pressure at engine.
2. Change in design of engine framing.
3. Increase in piston speed.
4. Use of superheat, but to a small degree only.
5. Reduction of clearances in cylinders.
6. Decrease of frictional losses through steam ports.
7. Positive circulation of steam through steam jackets.
8. Reduced back pressure in low-pressure cylinders.
9. Increased ratio between low-pressure and high-pressure cylinders, with consequent increased ratio of expansion of steam.
10. Application of forced lubrication to all journals, crosshead guides, eccentrics and thrust bearings.

The following improvements, both with reciprocating engines and with turbines, have been made:

11. Improved condensing apparatus resulting in higher vacuum.
12. Rational designs of feed heaters based upon the amount of water to be heated and the amount of auxiliary exhaust steam available for heating purposes instead of using the old rule of thumb of allowing a fixed horsepower per square foot of heating surface.
13. Basing steam-pipe design upon actual rate of flow of steam through the pipes as determined by tests in service.
14. Reduction of feed-pipe losses to a minimum.
15. Improved evaporators and other auxiliaries.

In addition to the above, the reliability of the machinery plant has been improved by—

16. Adoption of high-speed, electric-driven forced-draft fans for battleship.
17. Turbine-driven forced-draft fans for destroyers, and the most important of all—
18. The adoption of oil fuel for both battleships and destroyers.

Considering the above changes in detail, the steam pressures at the main engines since 1895 have been increased gradually from 150-lb. gage to 265-lb. gage in the high-pressure valve chest, resulting in decreased size of engine cylinders and in decreased size of steam piping for equal units of power.

The engine framing of the vertical engines first fitted

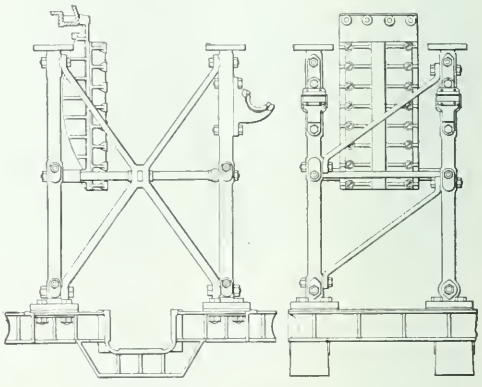


Fig. 2. New Type of Framing Adopted for the "Kearsarge" and "Kentucky"

*From paper read by Captain C. W. Dyson before the Society of Naval Architects and Marine Engineers. First part of the paper abstracted in Power of Jan. 7.

was either of cast steel or built up of steel plates, as shown in Fig. 1. On several vessels trouble has been experienced with this type of framing, particularly when made of cast steel, and, in addition, the weight was high. The Bureau of Steam Engineering, in order to overcome these faults, designed and adopted the style of framing shown in Fig. 2 for the "Kearsarge" and "Kentucky," and this style of forged-steel, built-up framing has been adhered to.

Since the adoption of this type, framing troubles are unknown notwithstanding the fact that the weight of the modern framing per indicated horsepower has been reduced to about 3.3 lb. against 5½ lb. for the old.

Since the design of engines for the "Oregon" was laid down, there has been a gradual increase in piston speeds used, from 900 ft. in that class to 1000 ft. in the "Delaware" class. This increase in piston speed has been followed by a decrease in weight of the moving parts and has aided in holding down the weight and height of the engine, although the stroke has been increased from 42 to 48 in.

In Fig. 3 are shown lines giving the maximum and minimum heights of naval engines for different lengths of stroke, also the line of crosshead pin centers and crankpin centers. These curves are all for engines having the bureau's standard ratio of four to one between the connecting-rod length and crankpin arm.

In the use of superheated steam the Bureau of Steam Engineering has been rather conservative; at present there are seven vessels in the naval service fitted for superheat, the maximum degree of superheat obtained at the boilers being 85 deg. F. which reduces to about 60 deg. F. at the engines. These figures are for full-power conditions, and an increase in economy of about 6 per cent. is estimated to be obtained. At 12 knots, the cruising speed, the saving by the use of superheat hardly exceeds 3 per cent.

The first experiences with the vessels fitted with superheat were far from satisfactory, due to the rapid deterioration of the valves in the steam lines. These valves had cast-steel bodies and cast-steel valve disks with monel metal seats. The erosion and corrosion of the valve disks was extensive, and in a short period of service it became necessary to replace the cast-steel valve disks with disks of monel metal. This substitution has been satisfactory and no further trouble has been experienced. The superheat has been used only on battleships fitted with reciprocating engines or impulse turbines for propelling purposes and has not as yet been used on any of the destroyers.

Reduction of clearances, decrease of frictional resistances of steam through the steam ports and reduced back pressures in the low-pressure cylinders have all resulted from one very important change in the design of

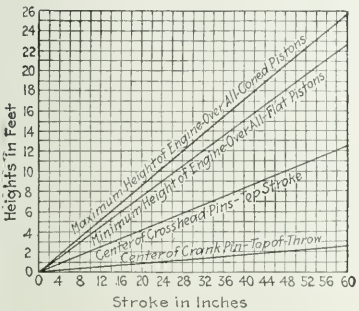

Heights in Feet
Stroke in Inches
Maximum Height of Engine Over All Coned Pistons
Minimum Height of Engine Over All Flat Pistons
Center of Crosshead Pins - Top of Stroke
Center of Crank Pin - Top of Throw

Fig. 3. Approximate Height of Marine Engines

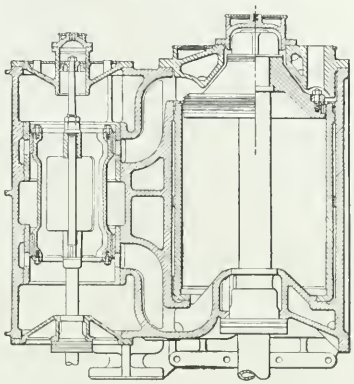


Fig. 4. H.P. Cylinder U. S.S. "Maryland." Clearance 27 per Cent.

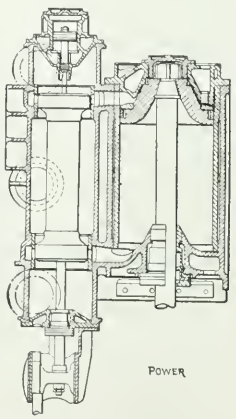


Fig. 5. H.P. Cyl. U. S.S. "Oklahoma." Clearance 10.75 per Cent.

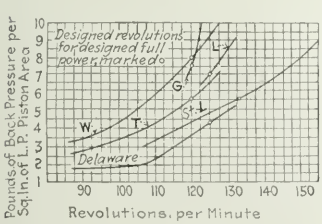

Pounds of Back Pressure per Sq. In. of L.P. Piston Area
Revolutions per Minute
Designed revolutions for designed full power, marked
Delaware

Fig. 6. Back-pressure Curves

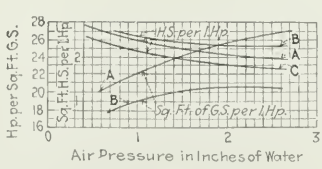


Fig. 7. Heating and Grate Surface per I.H.P.

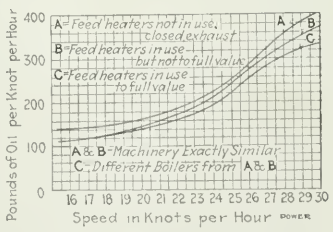

Pounds of Oil per Knot per Hour
A - Feed heaters not in use, closed exhaust
B - Feed heaters in use but not to full value
C - Feed heaters in use to full value
A & B - Machinery Exactly Similar
C - Different Boilers from A & B
Speed in Knots per Hour
POWER

Fig. 8. Increase of Oil Fuel with Speed

engine cylinders and valve chests. The original design of these cylinders is shown in Fig. 4, and the modern improved design in Fig. 5.

The results obtained by this change from the long, tortuous port to the short, direct port can best be shown by the accompanying table of comparison of cylinder clearances and steam velocities:

CYLINDER CLEARANCES AND STEAM VELOCITIES

	Old type	New No. 1	New No. 2	New No. 3
Diam. of cylinders, in.:				
H. P.	32½	38½	32	35
I. P.	53	57	52	59
L. P.	2-61	2-76	2-72	2-78
Stroke of pistons, in.	48	48	48	48
Per cent. clearances:				
H. P.	28	16 17	13 83	13
I. P.	20 8	13 17	12 65	13 5
L. P.	18 5	12 485	12 02	12
Steam velocity, ft. per min.				
H. P.	5,670	6,565	6,723	6,402
I. P.	8,262	6,678	7,883	7,517
L. P.	10,833	10,446	9,947	10,281
Exhaust velocity:				
H. P.	5,480	5,340	5,289	5,078
I. P.	6,670	6,180	5,909	6,087
L. P.	7,450	7,514	7,196	7,298
To condenser	7,390	6,637	6,612	6,560

To further illustrate the gains made by the short direct ports, attention is called to Fig. 6, where the back pressures on the low-pressure pistons of several vessels at varying revolutions are shown in the curves, the designed revolutions being marked on each curve by a circle. Of these vessels, the "Delaware" is the only one with the modern type of port.

In the last ten years, the cylinder ratio of low-pressure to high-pressure, for triple expansion engines, has been increased from about 7 : 1 to 10 : 1, including clearances. This increase in ratio had been used previously in remodeling the engines of the "Cincinnati" and "Raleigh," with most excellent results. A serious mistake was made, however, in counting too much on the increased expansions obtained by fitting a smaller high-pressure cylinder than that originally installed, the steam pressure having been increased. The new high-pressure cylinder was made 24 in. in diameter and the ratio of low-pressure to high-pressure cylinder changed to about 11½ to 1. While the economy obtained with these engines was most excellent, the high-pressure cylinders were entirely too small and the engines have never developed the expected power.

By the adoption of forced lubrication for the main propelling engines, the engine friction has been enormously reduced. All the journals are oil born so that no metal-to-metal contact occurs. The result has been that the amount of adjustment and overhaul of the main engines has been decreased to a large extent, and the men who would have been used for this overhaul work can now be used on the auxiliary machinery, to good advantage. This decrease in wear of the bearings, and the cushion provided by the oil, has resulted in a much better maintenance of alignment of the engines, has reduced shocks on the machinery and has reduced vibration due to these shocks. In addition, there is considerable saving in oil at ordinary speeds. At high speeds there still exists a heavy loss of oil, due to splashing on the cylinder heads and also to loss by evaporation from the hot surface of the lower heads.

When first fitted, the forced lubrication gave trouble, due to the oil being drawn through the low-pressure piston-rod stuffing boxes. To remedy this defect, stuffing boxes fitted with steam seals have been supplied, and later reports indicate that where the steam seal is properly fitted no trouble of this kind now exists.

That the foregoing changes have produced great economy is amply demonstrated by the results obtained with the machinery installations of the "Michigan," "South Carolina" and "Delaware." Fig. 7 shows curves of indicated horsepower per square foot of grate surface, and curves of square feet of heating surface per indicated horsepower for vessels fitted with the new type of engines and with boilers having superheaters, and also for vessels with the older type of engines and no superheat.

In laying down these curves, the actual generating heating surfaces and superheating surfaces have been retained, and the grates have been increased or decreased in order to have a constant ratio of heating to grate surface of 48.5, this being the ratio for the boilers of the "Minnesota." At the same time, the air pressures have been corrected inversely as the ratio of the new grates to the actual grates. The results obtained are shown as follows:

Curves of indicated horsepower per square foot of grate surface are:

A—With moderate superheat and modern engines.

B—No superheat and unimproved engines.

Curves of square feet of heating surface per indicated horsepower are:

A—Generating and superheating surface per indicated horsepower with modern engines.

C—Generating surface per indicated horsepower with modern engines and superheat.

B—Generating surface per indicated horsepower with unimproved engines and no superheat.

To obtain high vacuums, the Parsons vacuum augmentor is used extensively in the naval service. In some vessels in the service, in place of the ordinary air pump with augmentor, air pumps of the dual type, as manufactured by Weir, have been fitted, while in other vessels both wet- and dry-air pumps have been used.

Of these systems, that with augmentors and also the dual type appear to give the greatest satisfaction in service, and in addition require less weight and space than the wet and dry system. Abroad, a new system, known as the "Kinetic," has been developed, and all reports received concerning it have been very favorable, but no example of this system yet exists in the American naval service. In conjunction with these improved pump systems has occurred an improvement in the tube spacing and the baffling of the condensers in order that a better separation of air from the water of condensation will occur in the condensers.

The improvements in design of feed heaters, steam pipes and feed pipes naturally followed on the measurements of water consumptions of the machinery taken during the acceptance trials of the vessels. These measurements placed in the hands of the Bureau of Steam Engineering data of great value, and that bureau has attempted to use the full value of it in proportioning these important items. For instance, the feed heaters of the "Delaware" were, for lack of data, proportioned on the basis of so many indicated horsepower per square foot of heating surface, and the two heaters combined have a total heating surface of 2100 sq.ft. In her sister ship, the "Utah," the same degree of feed heating is obtained with heaters having a total surface of only 512 sq.ft.

In the search for economy, the Bureau of Steam En-

gineering has adhered strenuously to the use of feed heaters with auxiliary exhaust steam as the heating medium, using any excess of exhaust in the low-pressure turbines or the second receivers of triple-expansion reciprocating engines. This utilization of the auxiliary exhaust has not been to the taste of the turbine manufacturers who prefer to use all of this steam in the turbines, depending for feed heat upon that derived from steam drains discharging into the feed tanks.

That the bureau's contention that greater economy of fuel is obtained by the utilization of the auxiliary exhaust in the feed heaters is correct is shown by the curves in Fig. 8. The boilers of the vessels from which these results were obtained were so similar that the efficiencies may be taken equal, and the comparison can then be made on an assumption of 100 per cent. efficiency without much error. The fuel oil per knot is obtained from the heat units per knot absorbed by the boilers for the different speeds, and dividing these different heat unit values by an assumed British thermal unit value per pound of fuel. At 29 knots it will be seen that the vessel making full use of her feed heaters required only 84.2 per cent. as much fuel as the vessel putting all the auxiliary exhaust into the turbines (closed exhaust), and only 92 per cent. as much as the vessel using the feed heaters to a limited extent.

In evaporators the improvements consist mainly in the adoption of double effect connecting and in throwing open the gates to other than the standard bureau design although these are not the only changes from former practice. Evaporator feed heaters using the vapor from the evaporators as a heating medium have been fitted, and vapor pipes, better designed for the amount they have to carry, are installed.

Until the adoption of electric driven blowers for battleships and other large vessels and of turbine-driven blowers for destroyers and small vessels, the successful outcome of any heavy forced-draft run was always endangered by the unreliability of the blowers. Since the adoption of these types of blowers this danger of breakdown has been almost entirely eliminated, and so far as the destroyers are concerned, the blowers may be classed as one of the most reliable of the auxiliaries used in naval vessels.

What Captain Dyson had to say concerning oil fuel will be published in a later issue.

What Is a Horsepower?

By William Kent, M. E.

SYNOPSIS—The author remonstrates against the proposal of the U. S. Bureau of Standards to make the horsepower the exact equivalent of 746 watts, and shows that it involves either the use of an equally "inconvenient relation" in terms of foot-pounds or a change in the well established value of the pound.

Circular No. 34 of the Bureau of Standards defines a horsepower as 746 watts, and says its value in foot-pounds per second is not a constant but varies with latitude and elevation. The following is offered as a general discussion of the subject. We quote from the circular:

"The usual gravitational value for the English horsepower 550 ft.-lb. per sec., when reduced to watts gives a different number according to the value of the force of gravity employed in the conversion, and hence we find different values in various reference books."

The values cited range from 746, given in many books, down to 745.6 (Standard Handbook for Electrical Engineers, 1910, p. 21), Hering's Conversion Tables (1904, p. 81) give 745.650, and the Bureau of Standards Tables of Equivalents (1906) 745.6491.

"When the horsepower is taken as a specified number of foot-pounds per second, the amount of power represented by it varies for different places, since the weight of a 'pound,' as a unit of force, varies in value as g, the acceleration of gravity, varies. A unit of power, the magnitude of which varies from place to place cannot be acceptable, permanently as a unit." "Some writers prefer to define a pound weight as the weight of a pound mass at a particular latitude, such as 45 deg. (or some prefer the latitude of Paris). While this would make the pound of force a definite quantity, it is nevertheless open to the objection that a pound mass would in general have either more or less than a pound weight, depending on its location."

It may here be said that this objection applies to any system of weights and measures whatever, no matter what values may be given to the units. If a pound mass is a definite quantity of matter, and a pound weight is defined as the force which gravity exerts on that pound of mass then the weight will vary, as gravity varies, with the location. But if we define the unit of force with precision as the force with which gravity attracts a pound of matter at 45 deg. and the sea level, where $g = 32.1740$, and define a foot-pound as the work done by that force acting through a distance of one foot, and the horsepower as 550 of such foot-pounds per second, we have a precise value of the horsepower in English units, which has a definite relation to the watt, and which can be computed when we have the precise values of the meter and kilogram in English units.

"An uncertain definition of the horsepower might cause misunderstandings. No such confusion is possible if the horsepower is defined in such a way as to represent the same amount of power at all places."

No such confusion is possible if we define the horsepower as 550 ft.-lb. per sec., and if we define the foot-pound with precision as above described, the pound in the foot-pound being the force exerted by gravity on one pound of matter at 45 deg. and the sea level, or the force which, constantly applied to a pound of matter free to move, will give it an acceleration of 32.1740 ft. per sec. per second.

The Bureau of Standards neglects this easy method of arriving at a precise definition of the horsepower, which may be valued either in foot-pounds per second or in watts, abandons its former definition, the time-honored 550 ft.-lb. per sec., and its equivalent as formerly computed by the bureau, 745.6491 watts. It says:

"On account of well established use of 45 deg. as a standard latitude, the horsepower tables in this bureau's

Tables of Equivalents formerly assumed 550 ft.-lb. per sec. as the correct equivalent at 45 deg. latitude, which gave the inconvenient relation, 1 hp. = 745.6494 watts. Further editions of bureau publications will use the relation 1 hp. = 746 watts."

The inconvenient relation, it will be noticed, is carried out to the fourth decimal place, or to seven significant figures, indicating an order of precision far greater than that of the value of 39.37 in. in a meter, or than that of any determination of the acceleration due to gravity at any location, both of which values are used in converting foot-pounds per second into watts. The "inconvenience" might have been eliminated even with all practicable scientific precision, by changing the value less than one part in a million, adding 0.0006 watt, and making it 745.650, as in Hering's conversion tables.

Instead of doing this the bureau arbitrarily changes the value to 746 watts, stating that this is equivalent to 550 ft.-lb. per sec. at latitude 50 deg. (instead of 45 deg.) and makes the number of foot-pounds per second in a horsepower at latitude 45 deg., 550.28 instead of 550. It also gives a series of short tables, showing the value of the English and American horsepower (746 watts) in foot-pounds per second and in kilogram-meters per second, at various latitudes and altitudes. From these tables the following values are taken:

Lat. 0 deg. (equator) sea level 551.75; 10,000 ft. alt. 552.08
Lat. 45 deg. (equator) sea level 550.28; 10,000 ft. alt. 550.61
Lat. 90 deg. (pole) sea level 548.82; 10,000 ft. alt. 549.15

Approximate values: London 50 deg., 550; Washington 39 deg., 550.5; New Orleans 30 deg., 551. Taking the figure 550.28 as the value of the horsepower of 746 watts at lat., 45 deg. gives 550.28 : 550 : : 746 : 745.620.

The last figure represents the value of the horsepower (550 ft.-lb. per sec. at lat. 45 deg.) in watts, if we take the bureau's figure 550.28 as the correct figure corresponding to 746 watts. It does not correspond with the bureau's old figure 745.6494. It would appear that a new figure for the acceleration due to gravity at lat. 45 deg. was taken in computing the bureau's new tables.

In order to escape the "inconvenient relation" expressed by the figure 745.6494 and to obtain the more convenient figure 746, the bureau would put engineers to the inconvenience of looking up the tables showing the variation of the horsepower (when expressed in foot-pounds per second) every time they wished to convert foot-pounds per second into horsepower. It would have been much simpler if they had defined the horsepower as 745.62 watts, and stated that it was equivalent to 550 ft.-lb. per sec., giving the foot-pound the precise definition of the work of overcoming a force of one pound through a distance of one foot, and defining the unit of force, as before stated, as the force exerted by gravity on one pound of matter at 45 deg. at the sea level.

The bureau defined the watt as follows: "The watt is the power developed by the action with a velocity of one meter per second of a force capable of giving to the mass of one kilogram in one second a velocity of one meter per second."

Since force is defined (in the metric system) as equivalent, numerically, to the product of the mass (quantity of matter) in kilograms and the acceleration in meters per second per second, and taking g as the acceleration at any given place, the above definition may be converted into the following:

The watt is the power developed by the action with a velocity of one meter per second of $\frac{1}{g}$ of the force capable of giving to the mass of one kilogram an acceleration of g meters per second per second or more simply:

The watt is the power developed by the action with a velocity of one meter per second of $\frac{1}{g}$ of the force which gravity exerts upon the mass of one kilogram, at 45 deg. at the sea level, $g = 9.80665$, the value established by international agreement (Troisieme Conf. des poids et mesures, 1901, pp. 66-68; Marks & Davis' "Steam Tables and Diagrams," p. 93).

Taking this value of the watt and 550 ft.-lb. per sec. as the value of the horsepower, with one kilogram = 2.204622 lb. and one meter = 39.37 in., we obtain the relation between the watt and the horsepower as follows:

$$Power = rate\ of\ work = force \times velocity$$

$$1\ watt = \frac{1}{9.80665}\ kg. \times 1\ m.\quad per\ sec. = \frac{1}{9.80665} \times 2.204622 \times \frac{39.37}{12} = 0.73756046\ ft.\text{-}lb.\ per\ sec.$$

1 ft.-lb. per sec. = 1.35582105 watts
550 ft.-lb. per sec. = 745.70158 watts
1 hp. = 745.7 watts

The error, due to leaving off all the decimals but one, is less than 1 part in 472,000.

For all ordinary engineering work the engineer will use 746 watts as the equivalent of a horsepower of 550 ft.-lb. per sec., just as he uses 32.2 for the value of g instead of 32.1740, the more accurate figure (at lat. 45 deg.), and 778 ft.-lb. as the mechanical equivalent of the British thermal unit instead of 777.536, which is computed from Smith's value of the mean calorie 4.1834×10^7 ergs. (*Monthly Weather Review*, October, 1907), $g = 9.80665$, 1 kg. = 2.204622 lb., and 1 m. = 39.37; but when he wishes to have his results computed with accuracy beyond the third significant figure he should use the more accurate constants or tables based upon them.

If we should accept the bureau's advice and adopt 746 watts as the precise equivalent of the horsepower, and consequently give a variable value to the foot-pound, $\frac{1}{550.28}$ of a horsepower at 45 deg. lat., and sea level, and $\frac{1}{550.61}$ of a horsepower at 45 deg. lat., and 10,000 ft. altitude, etc., no end of confusion would result. For example:

A steam engine is tested at New Orleans, lat. 30 deg., and the following data are obtained:

Area of cylinder	330 sq.in.
Steam pressure	150 lb. absolute
Back-pressure	18 lb. absolute
Mean effective pressure	50 lb. per sq.in.
Piston speed	600 ft. per min.
Feed water temperature	200 deg. F.
Feed water consumption	12,000 lb. per hr.

Required the indicated horsepower, the steam consumption per horsepower-hour, and the thermal efficiency.

DATA FROM STEAM TABLES

B.t.u. per lb. steam, 150 lb.	1193.4
B.t.u. per lb. water, 200 deg. F.	167.9
Difference	1025.5

Computed results, engineers' method:

$$Hp. = \frac{P.L.N}{33{,}000} = \frac{50 \times 330 \times 600}{33{,}000} = 300\ i.hp.$$

Steam per i.hp. per hr. 12,000 ÷ 300 = 40 lb.

Heat equivalent of a hp.-hr. $= \frac{1{,}980{,}000}{777.5} = 2547$ B.t.u.

Heat expended per hp.-hr. $1025.5 \times 40 = 41{,}020$ B.t.u. Thermal efficiency $\frac{2547}{41{,}020} = 6.209$ per cent.

According to the Bureau of Standards methods, we would find from the bureau's tables that at New Orleans a horsepower is approximately 551 ft.-lb. per sec., and that a pound force at New Orleans is $\frac{550}{551}$ of the pound force at lat. 50 deg. Then we would have to consider what is meant by a pound in the data, 150 lb. absolute pressure at 50 lb. m.e.p. The first is measured by a pressure gage and the second by the spring of a steam-engine indicator. The first may have been standardized by dead weights in Washington and the second by dead weights in Boston and the standardization may or may not have been reduced to the equivalent at lat. 45 deg. or 50 deg. The figures taken from the steam tables are based on the fact that a pound pressure is equivalent to the force exerted by gravity upon a pound of matter at 45 deg. at the sea level or at any place where the acceleration due to gravity is 32.174 ft. per. sec. per sec. The constants used in the engineers' computations, 1193.4, 167.9, 1,980,000, 777.5 all are referred to a pound of force having a definite and constant value. Do any of these figures, or do any of those relating to pressures in the observed data need to be multiplied or divided by the ratio $\frac{551}{550}$ or by the ratio $\frac{551}{550.28}$ in order to obtain correct values for the horsepower, the steam consumption per horsepower per hour, or the thermal efficiency? The question may be referred to the bureau.

According to the bureau, the watt is the product of a definite force into a definite velocity. The force is $\frac{1}{9.80665}$ of a kilogram force, or of the force exerted by gravity on one kilogram at lat. 45 deg. The horsepower is defined as 746 watts. Why not define it also as the product of a force into a velocity, or as a convenient multiple (say 550 times) that product, and why not give a definite and precise value to the two factors of that product, viz.: the force in pounds and the velocity in feet per second? The precise definition of a pound force, as that force which will give an acceleration of 32.1740 ft. per sec. per sec. to a pound of matter, is in harmony with our modern steam and entropy tables and with all our conceptions of forces that are other than the force of gravity, such as the pressure of steam, the tensile strength of metals, the reaction of a spring, the pressure required to compress air, etc. This definition of the pound force is in exact harmony with the following definition given in Louis A. Martin's, Jr., "Text Book of Mechanics," vol. IV, p. 1: "The unit of force is the attraction exerted by the earth upon a certain piece of platinum when at a latitude of 45 deg. and at the sea level. This piece of platinum is marked P. S. 1844, 1 lb. and is carefully preserved in London."

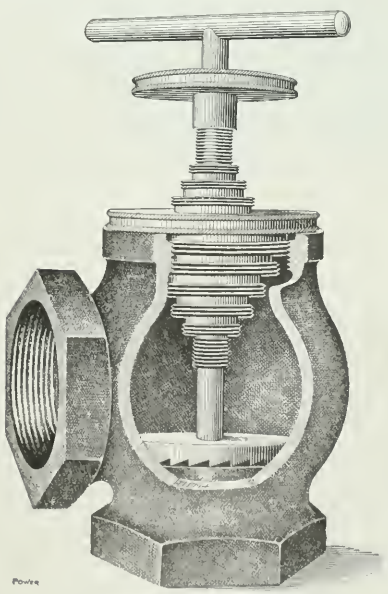
The only excuse given by the bureau for its new definition of the horsepower is that the figure formerly used by it in converting watts to horsepower 745.6494 is an "inconvenient relation," and that 746 is more convenient. The bureau's old figure has a great pretension to accuracy, but it is not nearly as correct (if we accept the international standard value of $g = 9.80665$) as the figure 745.7, which is almost as convenient as 746, and vastly more convenient than the set of variable values 550.28, etc., ft.-lb. given by the bureau.

The bureau's circular contains the following: "It is hoped that engineering societies and other interests concerned will recognize the value of the English and American horsepower as 746 watts, or 550 ft.-lb. per sec. at 50 deg. and sea level (approximately latitude of London), employing Table II to obtain the value in foot-pounds per second at other places."

It is hoped, from the engineer's point of view that the societies and other interests will commit no such blunder, but that on the contrary the bureau will withdraw its circular No. 34, and get itself in harmony with the best modern engineering practice by defining a pound force as the force which will give a pound matter an acceleration of 9.80665 m., or 32.1740 ft. per sec. per sec., and the horsepower as 550 ft.-lb. per sec. 33,000 ft.-lb. per min., which is equivalent to 745.7 watts.

Abbott Valve Reseating Machine

This simple device, manufactured by the Abbott Hardware Co., 636 Columbus Ave., New York City, is illustrated herewith. It consists of a knurled center disk with tapered threaded disks on either side, which fit into the bonnet opening of globe and angle valves, as shown. This tool is made for valves ranging from ⅛ up to 2 in. in size. Cutters are supplied with each machine suitable for different sized valves.



Valve-reseating Machine

To regrind a valve seat, the tool is screwed into the valve after fitting the proper size cutter to the spindle. The cutter is then turned by the handle, and the feeding is done by the top knurled handwheel, which prevents chattering of the knife, and insures a smooth seat.

The Augustine Rotary Engine

In a rotary engine of the type shown in Fig. 1 it is evident that the pressure in the active part, 31, of the cylinder will not only force the piston, 8, ahead, but will exert an equal force per unit of area upon that portion of the surface of the cylinder, 4, which lies between the running joint, 13, and the piston. As this cylinder is carried upon the main shaft, an excessive pressure, varying in magnitude and direction, is exerted upon the bearings. One of the modifications which the Augustine rotary engine has undergone since our description of it in the Dec. 21, 1909, issue is designed to overcome this difficulty.

If, as in Fig. 2, a second cylinder, 18, concentric with the piston cylinder, 4, be carried upon the same shaft and small apertures, 30, be provided to transmit the pressure existing in the chamber, 31, to the pockets, 14, formed by ribs, 16 (see also Fig. 5), upon the outer surface of the intervening abutment, 3, the pressure in the

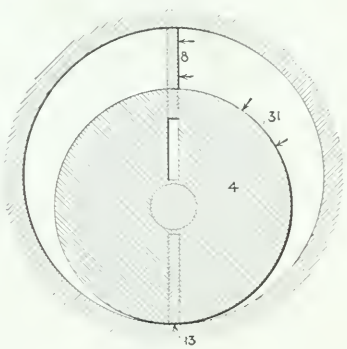


Fig. 1

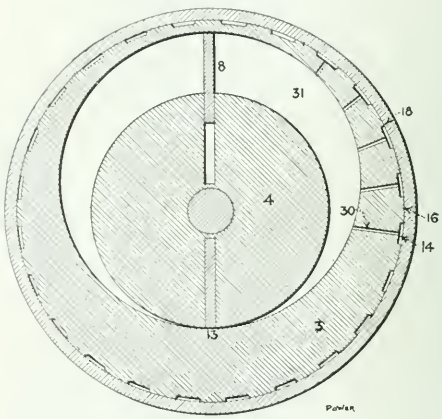


Fig. 2.

Showing Thrust on Bearings in Rotary Engine

acting cylinder will be transmitted to the inner surface of the balancing cylinder, 18, and the shaft be lifted thereby in a contrary direction to that in which it is forced by the pressure upon the piston cylinder, 4, relieving the pressure upon the bearings.

How this idea has been applied to the engine is shown by the accompanying engravings. Fig. 3 shows the piston cylinder, 4, with the pistons, 8, and one portion of the balancing cylinder, 18. A similar portion slips over the nearer head and the tongued inner edges of these balancing cylinders run in the grooved edges of the ring, 15, upon the center of the abutment, Fig. 5. The apertures leading from the cylinder to the pockets have check valves to prevent the return of the oil which is forced through them by centrifugal force and which creates a film preventing steam leakage. This central ring, 15, fits tightly into the casing, 2, Fig. 4, to which it is firmly bolted from the outside, and the balancing cylinders, 18, Fig. 3, run in the annular spaces, 19, Fig. 4, at either end. Openings in the ring, one of which is shown at 20 in Fig. 5 permit the steam to enter and escape. The admission ports are shown at 21 and the exhaust ports at 22 in Fig. 4. The joint, 13, in which the cylinder, 4, Fig. 3, runs is turned to the radius of that cylinder and provided with water grooves or pockets. That the balancing is effective may be demonstrated by removing the caps from the journal bearings when the engine is running. The shaft will be found to be floating freely.

The exhaust is valveless, taking place when the piston passes the upper ends of the ports, 22, Fig. 4. The admission and cutoff are controlled by a cylindrical valve, 6, Fig. 8, which is turned through an arc of a circle by means of the attached toothed segment which gears with a segment of twice its radius on the shaft, 7, which projects as shown in Fig. 4 and carries an arm which is attached to the shaft governor as shown in Fig. 9.

As with increasing speed the governor weights are thrown outward, the throw of the governor eccentric is decreased, the movement of the valve diminished and the point of cutoff made earlier. The multiplication of the movement of the valve by the use of the larger segment gives quick opening and closure.

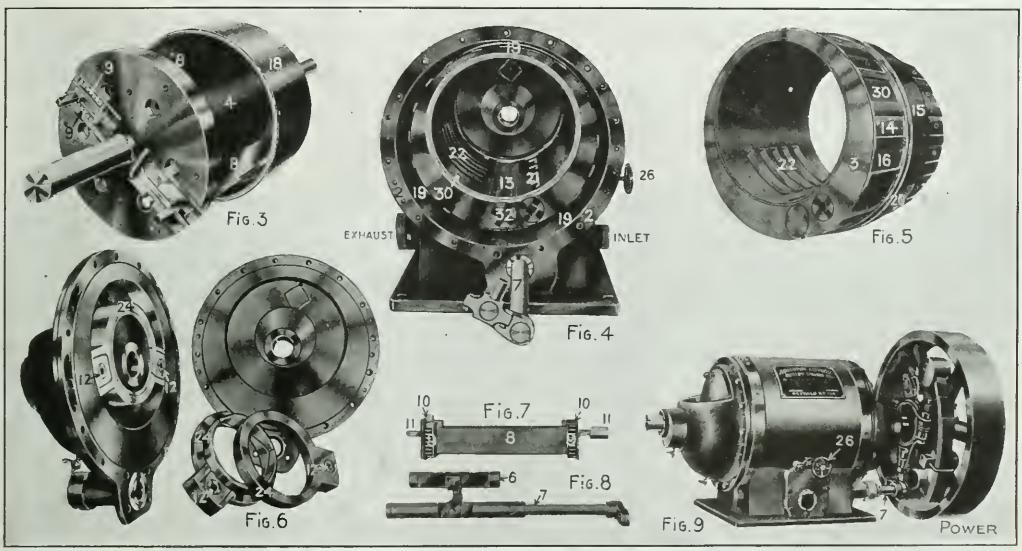
Other important sources of friction and wear in the earlier engine were the movement of the piston blades in and out against a heavy pressure and the scraping of the outer edge of the piston against the inner surface of the cylinder as it was thrown outward against it by centrifugal force. To reduce the first the pistons have been provided with roller bearings at their ends, as shown at 9 in Figs. 3 and 7, and to avoid their pressure upon the cylinder they are carried positively by the blocks, 12, Fig. 6, into which the bushed shanks, 11, of Fig. 7, fit. The centers of the overlapping rings, 24, Fig. 6, being eccentric to the center of the mainshaft, the distance between the holes, 12, and the shaft center changes as they are carried around in their eccentric path, and the pistons are positively carried inward and outward in their grooves with no other contact with the cylinder surface than is necessary for a tight joint.

The plate, 10, Fig. 7, closes the opening in the head of

the piston cylinder in which the pistons slide, as shown in Fig. 3. The spring-backed plug, 32, Fig. 4, runs against the inner surface of the head of the balancing cylinder, 18, Fig. 3, and prevents steam from blowing by the ends of the running joint, 13, Fig. 4, from the high-pressure side of the cylinder to the exhaust. The bearings are carried in the heads, as shown in Figs. 6 and 9, and are ring-oiled. In order to start the engine when it has stopped with the piston beyond the point of cut-off, a bypass valve, 26, Figs. 4 and 9, is provided.

Several hundred of these engines varying in capacity from 5 to 200 hp. and mostly of the earlier design have been built and are at work. The normal speed varies from 400 r.p.m. in the smaller sizes to 300 or 350 for engines of 200 hp., although the inventor claims that the smaller engines may be run as high as 2100 r.p.m. and places no limit upon the capacity for which he will take an order.

The engine shown in Fig. 9 is 19 in. long, 17 in. wide at the base, stands 20 in. high, has a shaft 48 in. long, is 17 in. outside diameter and weighs 800 lb. complete. Tested at the Ohio State University it delivered 39.69 b.hp. on 36.79 lb. of steam per b.hp.-hr., the steam being at a pressure of 106.7-lb. gage superheated 116 deg. and the exhaust into the atmosphere. The engine is built by the Augustine Automatic Rotary Engine Co., Buffalo, N. Y., and the Augustine Rotary Mill & Factory Engine Co., Mt. Vernon, Ohio.



The Augustine Rotary Engine. Figs. 3 to 9.

Decomposition of Steam by Heat

By Dr. Augustus H. Gill

Among the various means for the prevention of smoke is the jet of steam, used chiefly to suck in a current of air. This it certainly does, but it also gives an opportunity for the advancement of extravagant claims for the device as a gas producer; I remember seeing the legend "Hydrogen Gas Retort" upon a circular of such a device.

One of the claims commonly advanced, is for great economy due to the decomposition of the steam by the hot coal. While this is true according to the reaction

$$\underset{\text{coal}}{\text{Carbon}} + \underset{\text{steam}}{\text{hydrogen oxide}} = \text{carbonic oxide} + \text{hydrogen}$$

yet there can be but little or no economy in it, because heat is used up in decomposing the water. This fact is lost sight of by the advocates of such apparatus. The reaction that has taken place is analogous to rolling a heavy stone up hill. When the enthusiasts over first aids to combustion of this kind point out "the amount of work that can be done if the stone be allowed to roll down;" they appear, as it were, when the stone is at the top of the hill, to forget, and make the victim forget, the toil necessary to get it there.

Similarly they disregard, and make others lose sight of, the energy used up in decomposing the steam. There is practically nothing to be gained by this operation because the heat that the combustion of the hydrogen produced is exactly equal to that used up in the decomposition of the steam. There may be a slight economy in that the carbonic oxide formed may be consumed to better advantage than the coal from which it is made. The temperatures required for the decomposition of steam by coal are from 1215 deg. F., when about 9 per cent. is broken up, to 2057 deg. F.* when it is practically all decomposed.

Another claim, and one even more preposterous, is that by passing steam through white-hot iron retorts or pipes it is decomposed into hydrogen and oxygen, of which one is available as a fuel and the other as an aid to combustion. This probably comes from the fact that when the apparatus is new, hydrogen will actually be found in the gases issuing from it. It is not formed from

*Bunte J. Gas Lighting 53, p. 481.

the decomposition of water into hydrogen and oxygen, but in accordance with the well-known fact that red-hot iron will decompose steam according to the reaction:

iron + hydrogen oxide = iron oxide + hydrogen

This has been made use of for many years for the protection of iron fittings and is called the Bower-Barff process. When, however, the pipes and retorts become thoroughly coated with this oxide of iron, (forge scale, magnetic oxide) no further decomposition of the steam can take place.

The practical difficulties in the way of this claim are:

First, it is impossible to heat steam hot enough in a coal-heated furnace to decompose any usable amount.

Second, if it were decomposed, when it is cooled down, for example to pass the mixture under the grate, the hydrogen and oxygen would recombine, and merely superheated steam result.

Third, at the temperature necessary to decompose any appreciable quantity of steam, the iron (even wrought-iron) fittings would be melted and give way under the pressure.

Fourth, if it were possible to dissociate steam under these conditions there would be nothing gained, for the reason given above, in the decomposition with carbon; the heat absorbed in the decomposition of steam is only just returned in the combustion of the hydrogen and oxygen formed.

Lowenstein and Wartenburg in 1906* showed that at 2060 deg. F., about the melting point of average cast iron (1912 deg.—2310 deg.) steam was but 0.0086 per cent. decomposed; and even at a temperature but little above that of melting wrought iron (2900 deg. F.) only one-third of one per cent. was dissociated.

This means that in cast or wrought-iron retorts practically no steam can be decomposed into hydrogen and oxygen; and if there were any of these gases formed, inasmuch as the reaction by which they are formed is under the conditions a reversible one, that they will recombine the moment the temperature is lowered.

From these considerations it would seem to be clearly impracticable to use the process in boiler practice.

*Zeit. f. physik. Chem. 54, 715.

Visit to the Mesta Machine Shops

The Engineers' Society of Western Pennsylvania visited the shops of the Mesta Machine Co., at West Homestead, on Saturday, Dec. 28.

A shop like that of the Mestas is always full of interest, but upon this occasion there were upon the floor two engines of more than ordinary account: the larger of these was a twin-tandem compound-reversing engine to be installed in the works of the Youngstown Sheet & Tube Co. It has two 46-in. high-pressure cylinders and two 76-in. low-pressure cylinders, with a common stroke of 60 in. The maximum speed is 200 r.p.m., and it is said to be the most powerful rolling-mill engine ever built. The throttle and reverse gears are controlled by a single lever, which has the advantage of simplicity and compels the engineer to run always with the most economical cutoff. The engine also has a more direct drive and a less complicated valve-gear, with fewer parts than are used on the usual engine of the rolling-mill type.

The smaller unit was a direct-flow steam engine to be installed in the power plant of the Carnegie Institute of Technology. It has a single cylinder 28 in. in diameter by 42-in. stroke, and is a modified Stumpf unidirectional-flow engine, having Corliss steam valves in the head and Corliss exhaust valves at some distance toward the center from the head, thus making a pocket in the hot end of the cylinder. It has not the central valveless exhaust port, and the piston is therefore much shorter, resulting in a much shorter cylinder than in the usual Stumpf engine. On account of the lesser compression also a smaller cylinder diameter can be used, and they were able to obtain this modified form of the Stumpf adapted to noncondensing operations, at a cost something like 30 per cent. below that of the full-fledged unidirectional-flow machine. This engine is guaranteed to run on 27 lb. of steam per kw.-hr., the pressure being 175-lb. gage with 100 deg. of superheat and the exhaust into the atmosphere.

The guarantees for noncondensing steam turbines ran from 35 to 47 lb. per kw.-hr. under the same conditions.

We are promised details and illustrated descriptions of these engines as soon as they are in position and have demonstrated what they can do.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA AT MESTA MACHINE CO., WEST HOMESTEAD, PENN.

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Dynamo and Motor Characteristics

Every direct-current machine of regular construction may be operated either as a dynamo or as a motor. There is no difference between the two machines except in their controlling apparatus; used as a dynamo, the machine is provided with a high-resistance rheostat connected in series with the shunt field winding; used as a motor, it is provided with a low-resistance starting rheostat connected in series with the armature.

The speed of a given machine, when operating as a dynamo, must be appreciably higher than that at which it runs as a motor, if the voltages are the same in both cases. The drop of voltage in the armature circuit causes this difference in speed. For example, if a dynamo delivered 110 volts and 100 amp. running at 1150 r.p.m. and the resistance of the armature circuit were 0.05 ohm, the drop in the armature circuit would be

$$100 \times 0.05 = 5 \text{ volts}$$

and the total electromotive force generated in the armature winding would be 115 volts; 110 delivered at the brushes and 5 absorbed by the internal resistance.

If that same machine were operated as a motor on a 110-volt supply circuit and given a load that caused the armature to take 100 amp., the drop in the armature circuit would be 5 volts, as before, but this would be subtracted from the impressed electromotive force of 110 volts, leaving 105 volts to be balanced by counter electromotive force. As the armature generated 115 volts at 1150 r.p.m. when driven as a dynamo, it will generate 105 volts at 1050 r.p.m. This, therefore, will be the speed when running as a motor, with the same armature current as before.

The foregoing statements apply to either a shunt-wound or a compound-wound machine, but with the latter type (to get the same comparison) the connections of the series field winding must be reversed in order that the magnetizing effect of the winding may be the same in both cases. Figs. 121 and 122 will assist in making it clear why this is true. In the dynamo, Fig. 121, the current flows *from the positive brush to the line* through the series winding, exciting that winding in the same direction that the shunt winding is excited. Running as a motor (Fig. 122), the current flows *from the line to the positive brush* through the series winding, exciting the latter in the opposite direction. Reversing the terminals of the series winding, as in Fig. 123, corrects this.

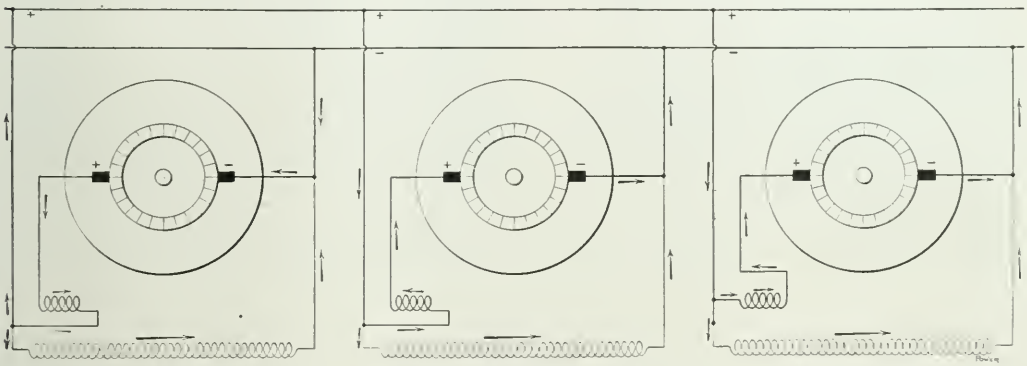


Fig. 121. Compound-wound Machine as a Dynamo

Fig. 122. Compound-wound Machine as a Motor, Connections Unchanged

Fig. 123. Connections Corrected for Running as a Motor

A compound-wound dynamo can be used as a motor without changing the connections of the series field winding, but it is not usually advisable because when this is done the machine becomes a differential compound-wound motor and therefore has a relatively small starting torque, owing to the weakening effect of the series winding on the field magnet. Such a machine also tends to increase its speed as the load increases, and with a very heavy load may "break down" and stop running, due to the reduced armature torque. This could readily happen if the ampere-turns in the series field winding at full load were a large proportion of the ampere-turns in the shunt winding.

For example, if the shunt field winding contained 1000 ampere-turns and the series field winding 2000 (at full load), the total full-load excitation, with the windings magnetizing in the same direction, would be 6000 ampere-turns. Suppose, for convenience, this produced a flux of 6,000,000 maxwells and that the armature torque developed by this flux and full-load current was 300 lb.-ft. Also suppose that 2000 ampere-turns of excitation would produce 3,000,000 maxwells, or one-half of the normal

flux. Then, with the series winding opposing the shunt winding, the net field excitation would be

$$4000 - 2000 = 2000 \textit{ maxwells}$$

and the result would be one-half the correct flux and, consequently, one-half the full-load torque with full-load armature current flowing. If the armature could speed up to twice its normal rate without increasing its load, that is what it would do, because of the halved field flux; and it would deliver the normal full-load work. But if the load were such that it increased with the speed, the motor could not speed up because its torque would not be

FIG. 124. DIRECTION OF ARMATURE PULL

strong enough to pull the increasing load; it would probably "break down" and stop.

To use a series-wound dynamo as a motor, or *vice versa*, either the terminals of the field winding or the connections at the brushes must be reversed, if the armature is to run in the same direction as before. If the direction of armature rotation be reversed, no change need be made in the connections of the machine.

DIRECTION OF ROTATION

The direction in which a motor armature will revolve when supplied with current depends on the connections between the field winding and the brushes. The reason for this is that the direction in which the current flows through the armature wires *with respect to the polarity of the field magnet* determines the direction of armature torque or pull, as explained in the recent lesson on the electric motor. Thus, if current be sent through the wire loop on the armature core in Fig. 124 in the direction indicated by the arrowheads, the core will tend to turn in the direction of the curved arrow. If the current be reversed in the wire loop, the core will tend to turn in the opposite direction. If the current flow be as indicated by the arrow-heads and the field magnet polarity be reversed, the direction of the armature pull will be reversed.

The direction of the current through the armature wires depends on the direction of entrance and exit at the brushes, and the polarity of the field magnet depends on the direction of current flow through the field winding; hence the truth of the statement at the beginning of the preceding paragraph.

Fig. 125 is a diagram of a shunt-wound motor in which it is assumed that with current flowing through the armature and field windings in the directions indicated by the arrows, the armature will revolve in the direction indicated by the arrow *R*. If the wires leading to the brushes be transposed, as in Fig. 126, the direction of the current through the armature wires will be reversed and the armature will therefore revolve in the opposite direction, indicated by the arrow *R*. Again, if the armature connections be left as in Fig. 125 and the field leads be reversed, as in Fig. 127, this will reverse the field magnet polarity and the armature will revolve in the opposite direction to that in Fig. 125.

If all of the motor connections be left as in Fig. 125 and the leads from the main terminals to the supply circuit be transposed, making the right-hand motor terminal positive and the left-hand one negative, the direction of rotation will not be changed, because both the current in the armature wires and that in the field winding will be reversed and the direction of the current through the armature wires *with respect to the field polarity* will be unchanged.

The foregoing statements regarding the direction of motor rotation apply also to self-exciting dynamos. If the armature of such a dynamo be driven in the opposite direction to that for which it was intended, it will not generate current unless the connections between the field winding and the brushes be reversed. Figs. 128 to 130 show why this is true. If the armature generates an electromotive force in the direction indicated by the arrows *E*, *E*, Fig. 128, when driven in the direction of the curved arrow and with the field current flowing as indicated, reversing the direction of rotation will reverse

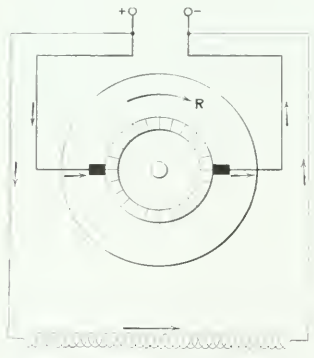


FIG. 125. SHUNT-WOUND MOTOR FOR RUNNING IN NORMAL DIRECTION

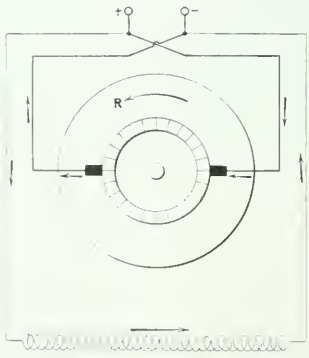


FIG. 126. ARMATURE CONNECTIONS REVERSED FOR REVERSE ROTATION

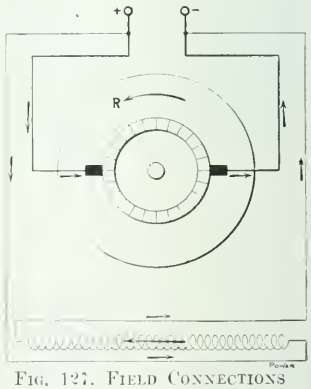


FIG. 127. FIELD CONNECTIONS REVERSED FOR REVERSE ROTATION

the direction of the electromotive force, and, to continue the field excitation in the same direction as before, the connections to the brushes must be reversed, as in Fig. 129.

If the connections between the field winding and the brushes are not reversed, the machine cannot excite itself with the armature rotation reversed, because the direction of the electromotive force generated by the armature will be opposite to the direction of current flow required in the field winding. Fig. 130 illustrates this condition. With current flowing through the field winding in the direction of the arrow and supplied from some other dynamo, the armature electromotive force will be in the direction of the arrows *E, E*. Therefore, if the field winding were connected to the brushes as in Fig. 128, the polarities would be wrong and the armature could not excite the field magnet and consequently could not generate current.

A shunt-wound machine when running as a motor will run in the same direction in which it is driven when operating as a dynamo. Comparison of Figs. 125 and 128 will make this clear. The former shows the direction of current flow when running as a motor. As the counter electromotive force of a motor armature is opposite in direction to the flow of current sent through the armature from the line, arrows indicating the generated electromotive force in Fig. 125 would be as shown at *E, E*, Fig. 128; therefore the latter diagram shows the dynamo conditions for the machine represented as a motor in Fig. 125. Note that the direction of rotation is the same in both cases.

A series-wound machine when operated as a motor will run in the *opposite* direction to that in which it must be driven to operate as a dynamo. This fact is of very little practical importance, however, because it is very seldom that any occasion arises for using a series-wound dynamo as a motor or the reverse. Should such a change be desired, it would be necessary to reverse either the direction of rotation or the connections at the brushes of the machine.

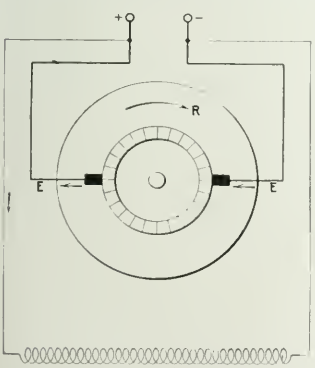


Fig. 128. Shunt-wound Dynamo Normally Connected

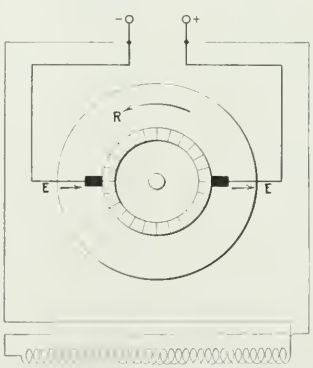


Fig. 129. Field Connections Reversed for Reverse Rotation

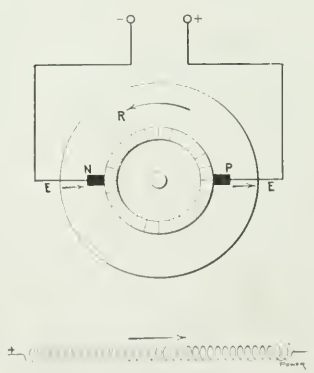


Fig. 130. Reverse Rotation with Separate Excitation

Dynamo "Breakdown" Point

If the load of a shunt-wound dynamo be increased beyond a certain point, the machine will lose its field magnetism and stop generating. This is because the drop in the armature circuit reduces the electromotive force at the brushes to such a point that the field excitation drops below the point of "stability." This carries the reader back for a moment to a consideration of the excitation curve. Fig. 131 is such a curve; the reason for its shape was explained in an early lesson. This curve was plotted from the data of a 220-volt dynamo. The numbers on the horizontal scale at the bottom of the chart are voltages at the terminals of the field winding. The vertical scale shows voltages generated by the armature corresponding to the different excitation voltages. For example, with 90 volts at the field terminals the armature generated 140 volts; with 110 exciting volts, it generated 200 volts, and with 210 volts at the field-winding terminals the armature generated 210 volts.

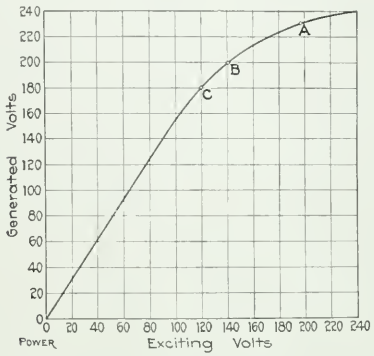


Fig. 131. Excitation Curve of a 220-volt Motor

Now suppose the resistance of the armature circuit to be 0.1 ohm and the drop at the brush faces to be 2 volts at all loads. With 330 amperes going through the armature the total drop would be

$$33 + 2 = 35 \text{ volts}$$

so that the exciting volts would be 35 less than the gen-

erated volts. This condition exists when the generated volts are 230 and the exciting volts 195; that is, at the point A on the curve. Increasing the load to 580 amp. would make the drop 58 volts in the armature plus 2 at the brushes, or 60 total. The exciting volts would therefore be 60 less than the generated volts. The machine might be stable under this condition at the point B on the curve, where the generated volts are 200 and the exciting volts are 140, but that is doubtful because it could drop to the point C and still have a margin of 60 generated volts above the exciting volts.

Any further increase in load will "break down" the machine—that is, cause it to lose its magnetization and stop generating, because the difference between the exciting and generated volts would be greater than it could stand. For example, if the load were increased until the total drop through the armature and brushes were 65 volts, the machine could not generate enough voltage to excite the field, because there is not a point on the curve where the machine generates 65 volts more than the pressure required to excite the field.

In the example just given, no account was taken of the weakening effect of armature reaction upon the field, because that subject has not yet been considered. The influence of armature reaction merely hastens the "breaking down" of the dynamo, causing it to occur higher up on the excitation curve than it otherwise would.

In practice, a well-designed machine never reaches the break-down point because it is built to work at a point so far up the excitation curve that the armature current would have to be about three times the full-load current to cause enough drop through the armature circuit to make it let go.

Losses in Turbo-Alternators*

The total iron and copper losses in a large, high-speed turbo-alternator are in general no higher than in a corresponding capacity low-speed machine.

As far as the iron losses are concerned, no further comment need be made than that the magnetic flux densities in general are somewhat lower than in lower speed machines of the same frequency, and therefore the losses per unit volume of material are no larger.

The total armature copper losses in turbo-alternators, as a rule, are considerably smaller than in corresponding capacity machines of the moderate- or low-speed types. This is due partly to the use of a smaller total number of conductors, and partly to a lower current density in the armature conductors. In a narrow-core machine, a considerable portion of the buried copper heat may be conducted lengthwise of the conductor into the end winding, and there dissipated into the air. In the turbo-generator, with its much wider core and greater distance from the buried copper to the end windings, a smaller percentage of the buried copper heat will be conducted into the end windings.

To partly compensate for this, it is usual to work the armature copper in the turbo-generators at a lower current density, and, therefore, at a relatively lower total copper loss. This is somewhat of a handicap in the economical design of the generator, as extra space is thus required for the armature winding. In some of the earlier machines, the armature conductors were made of solid copper bars of relatively large section, partly for stiffening or bracing the end windings. With these solid conductors there was a very considerable loss in the buried copper, due to eddy currents. To compensate for this, the armature conductors were made very large in section, so that the current density, due to the work current alone, was very low compared with practice in other types of machines. On account of the comparatively large section of armature conductors, the conduction of heat from the buried copper to the end windings was relatively large.

In some of these earlier large capacity machines, the nominal current density in the armature conductors was so low, and the section of conductors so great, that the total buried copper loss, due to the work current, could be carried from the buried part of the coils into the end windings with a comparatively small drop in temperature, so that, if there had been no eddy currents present, the buried copper would have shown less rise than the iron. Any considerable rise which occurred was thus chargeable to eddy currents in the buried conductors, rather than to the work current. While such construction was fairly effective for the purpose, yet it was decidedly uneconomical in design. In fact, with later proportions and methods of design, the safe outputs of some of the earlier machines could easily be 50 to 75 per cent. greater, largely on account of elimination of eddy currents and improvement in methods of dissipating heat from the end windings.

In many of the older machines, the ventilation of the end windings was not nearly as effective as in modern types, due principally to the form and arrangement of the end connectors. Usually air spaces were allowed between adjacent coils, although, in some instances, these were so small as to give but little benefit. Moreover, in many cases, the type of end winding employed rendered these air spaces between coils rather ineffective, unless special means were taken to deflect the air between the coils. With later constructions, the end windings lie more or less across the path of the ventilating air, and there are ample openings between the coils, so that a very considerable part of the ventilating air will actually pass between the coils of the end windings in such a way as to give the maximum possible ventilation. When it is considered that the total armature copper loss may be only 20 per cent. of the total stator loss, it will be seen that an excessive amount of air is not required when the end windings are arranged for most effective ventilation.

Much effort has been expended in eliminating or reducing the eddy current losses in the buried copper of large turbo-generators, as well as in other types of large capacity alternators. These eddy currents are due to two sources, namely, the alternating magnetic flux across the slots, due to the armature ampere turns per slot, and secondly, the magnetic fringing from the rotor pole face into the open armature slots. In some instances, tests have indicated that the local electromotive forces set up in the armature conductors by the flux through the slot opening are much greater than those due to the flux across the slot.

The simplest remedy for the eddy currents set up by these local electromotive forces is to subdivide the conductors into a number of wires or conductors in parallel, so arranged or connected that the local electromotive forces oppose and, to a great extent, balance each other.

*Excerpt from a paper by B. G. Lamme, read before the American Institute of Electrical Engineers, New York, Jan 10, 1913.

GAS POWER DEPARTMENT

Lubrication of Gas Engine Cylinders

By A. L. Brennan, Jr.

The fundamental principle of lubrication is to present an ever-constant film of some non-friction element between two rubbing surfaces irrespective of their speed or the load they carry. Some authorities argue, however, that the cylinder is the all-important part to be considered in an internal combustion motor and allow that most any provision will take care of the remaining parts of the machine. This supposition is alluring as applied to any machine, especially a gas engine, considering that its operation is dependent upon all its parts, not in decreased ratio, according to the apparent value of the part, but entirely. To some this may appear rather unusual but when it comes to practical operation the value of this point is at once recognized. In regard to the cylinder and piston lubrication of a gas engine there are three important points to be considered:

An oil having a flash point of at least 390 deg. F. or nearer 450 deg. is absolutely necessary in order to perform its functions at the high cylinder temperatures.

Another point to be considered is the specific gravity which although given little consideration is important; for unless an oil ranges in specific gravity from 26 to 30 deg. Bé. it will not prove so effective.

The viscosity should range from 180 to 220 at 80 deg. F.

Viscosity is made up of two properties: cohesion and adhesion. The former is that property of the oil that binds its particles together. The greater the cohesion, the greater the pressure which the oil will resist without losing its function of being present in the form of a film; hence an oil possessing excessive cohesion properties will be more suitable under heavy loads, for if the cohesive property were low, even an excessive amount of oil might not prevent the bearing surfaces from rubbing.

Adhesion in an oil is that clinging property which causes it to adhere to other bodies; that is, its tendency to remain on the bearing surfaces. Therefore an oil to be truly effective must be not only cohesive but adhesive as well. The same applies to the non-fluid oils and

All oils to be suitable and effective in gas engine cylinders should be by-products of petroleum, that is some form of mineral oil. Animal and vegetable oils are quite adapted to the other parts of a gas engine where excessive heat is not encountered, but prove absolutely unpractical for the cylinder.

It must be borne in mind, however, that all petroleum oils are not adapted to gas engines in general and can not be adapted to any one machine in particular, and so it is found necessary to select an oil which will meet the several existing contingencies advantageously in order to realize the highest efficiency from a motor. Oils which conform with the specifications mentioned but possess a thin body are undoubtedly the best. Many harbor the erroneous idea that an oil to prove an efficient lubricant must have considerable body, this is altogether wrong as the thinnest oil that will remain in a bearing will invariably give the best results. Of course, under certain circumstances such as in the case of a warm bearing or for heavy pressures oil possessing considerable body will be useful, but otherwise its function will be impaired by the frictional resistance offered by its thick body.

Cylinder oils adaptable to one motor are not necessarily suitable for another. For instance, a high-speed machine lubricated by a splash system, that is, by the cranks dipping into oil contained in the base,—requires a light or medium oil. On the other hand, in heavy duty slow-speed engines dependent upon oil supplied from an oiler of the force feed type, an oil of more body will give slightly better results. But the thickest oil that will flow readily in the grooves, should not be used; instead an oil that will distribute readily and evenly when it reaches the surfaces should be selected.

Thin oil will flow rapidly and in the case of the piston oiling will provide suitable lubrication for the piston rings. This is a most important feature, for if the rings in a gas engine are not kept free from carbon and other deposits they will not move freely in their grooves, inducing additional pressure on the cylinder walls with resultant wear which eventually leads to impaired compression and diminished power.

Faulty cylinder lubrication is invariably attributable to one of two causes, or both—insufficient lubrication with good oil or correct amounts of poor oil. It sometimes occurs, however, that good oil is used in too large a quantity. An excessive amount of oil either of a high or a low flash point will bring about detrimental effects. The first indications in the case of using a poor oil are manifest in decreased power due primarily to the friction offered the surfaces of the piston and cylinder, secondly to faulty compression due to the piston rings becoming inoperative and thirdly to carbon deposits, which materially reduce the efficiency of the valves and impair the function of the spark plug, subsequently inducing pronounced carbon deposits that become incandescent and cause preignition.

Good oil will lead to the same results if too much is used; hence it is evident that a proportional amount of oil, according to the size and speed of a motor, is necessary before the best results can be had. A motor that requires say eight drops of oil per minute per cylinder at 500 r.p.m. will require more oil when the speed is increased, as the piston's travel will cover a greater area. This condition is amply taken care of on motors using the splash feed system or mechanically-driven lubricators, for the supply of oil allowed decreases and increases with the speed; but unless the first adjustment is correct the increased amounts, when the motor is speeded up, will be proportionately at fault.

By procuring the best grades of any of the popular brands of cylinder oils an operator may feel confident as to the thorough lubrication of the piston directly and indirectly. By "indirectly" reference is made to the wrist pin. This important yet often neglected bearing is in many instances taken care of by a portion of the oil supplied to the piston surfaces. This oil works along the surfaces of the piston as far as the oil retaining ring which has a tendency to maintain a constant feed of oil, but it at the same time directs a small amount of oil to the grooves leading to the wrist pin. Here again the importance of employing an oil of comparatively thin body yet of good viscosity is essential for the creeping ability of a thick oil might militate against its travel to such a degree as to render it impractical for this purpose. Also an oil of low flash point would quickly carbonize in the high temperatures and the rings.

Operators have a tendency to put up with an inferior grade of cylinder oil rather than pay the high prices now asked for a first-class product. This is a poor policy for not only is the output of the machine reduced but the wear and tear to which a motor is subjected when employing inferior grades of oil is decidedly on the negative side of a profit and loss account. Poor lubricating oil not only impairs the mixture by a partial combustion of its own elements but by not keeping the wear at a minimum, allows lower compression which in turn puts greater demands upon the ignition current. Considering the mechanical depreciation of a motor alone the slight additional expense of using the very best oils obtainable is to be recommended.

A good plan to follow, when considering the high price of the best oils, is to use the best grade cylinder oil for the cylinder only and any good machine oil for the other parts of the motor. Of course, in motors employing the splash feed system, there will be but little saved, as nearly all the bearing parts are looked after by the "splash," but on motors having force lubricators or oil cups for the cylinders a marked saving can be attained by using two oils. Find out by experimenting as early as possible the correct amount of oil necessary to produce the best results and then keep that amount constant.

If by any chance you are compelled to employ another make or grade of oil which may appear to the naked eye to be similar to the first, you should use the same precaution to ascertain if your surmise is accurate, that you did at first, for the new oil may not feed as fast which would result in under-lubrication or it might be even more subject to heat than the first and feed at a greatly increased rate with the detrimental effects pertaining thereto.

❖

A natural-gas pipe line, 124 miles long and 12 in. in diameter, is now in course of construction in California for the Midway Gas Co. The operating pressure on this line will be 450 lb. per sq.in., the highest yet employed for this purpose.

The Junkers Engine—VII

By F. E. Junge

The increase in dimensions of small engines in direct ratio to the growth of capacity is restricted in several ways. Good scavenging and perfect combustion exact a ratio of length of stroke to cylinder diameter of at least 1.5. The piston speed also acts prohibitively, inasmuch as it depends upon the inertia pressures, the frictional resistances, and the lubricating conditions. With the enlargement along these lines limits of practicability are soon reached, making reliability and economy a serious problem. The following power schedule, of two-stroke-cycle, single-acting Diesel and Junkers engines in tandem arrangement, will elucidate the foregoing.

The following assumptions are made: in the Diesel engine a ratio of stroke to diameter of 1.5, and a piston speed of 16.4 ft. per sec. (5 m. per sec); in the Junkers engine a ratio of stroke to diameter of 2, and a piston speed of 11.5 ft. per sec. (3.5 m. per sec.). The mean pressure referred to the shaft horsepower has been assumed at 71.2 lb. per sq.in. (5 kg. per sq.cm.) for both engines. For the two-stroke-cycle single-acting Diesel engine the indicated horsepower per cylinder is then expressed by the equation:

$$I.hp. = 0.167 \frac{\pi d^2}{4}$$

For the Junkers tandem engine

$$I.hp. = 0.467 \frac{\pi d^2}{4}$$

From these formulas the following table has been computed:

	Diesel engine with piston speed = 5 m. per sec.				Junkers tandem engine with piston speed = 3.5 m. per sec.				
Output in hp.	Diameter of cylinder, mm.	Stroke, mm.	R.p.m.	Maximum piston-force for p = 40 kg. per sq.cm.	Length 7 x stroke, m.	Diameter of cylinder, mm.	Stroke, mm.	R.p.m.	Maximum piston-force, kg.	Length 8.5 x stroke, m.
300	480	720	210	72,000	5.0	290	580	360	26,p00	4.9
400	550	825	180	95,000	5 8	330	660	320	34,000	5 6
600	680	1020	147	145,000	7 2	400	800	260	50,000	6.8
800	780	1170	128	191,000	8 2	470	940	224	69,000	8.0
1000	880	1320	114	243,000	9 2	520	1040	200	85,000	8 9
1200	960	1440	104	290,000	10 1	570	1140	185	102,000	9.7
1500	1070	1600	94	360,000	11 2	640	1280	184	129,000	10.0
1800	1170	1760	85	430,000	12 3	700	1400	150	154,000	11.9

This tabulation shows the superiority of the Junkers engine in tandem arrangement over the two-stroke-cycle, single-acting Diesel engine. Although the ratio of stroke to diameter has been taken very large, the total length of the Junkers engine is less than that of a Diesel engine of the same power. Under the same circumstances the maximum gas pressure on the piston is approximately three times less than that in the Diesel engine. The weights and first costs are decreased accordingly.

Regarding the development of the power-transmitting mechanism of the Junkers engines as a combination of the mechanism of several single-acting Diesel engines, there is this to say: In a two-cylinder two-stroke-cycle vertical Diesel engine (see Fig. 37) the energy is transmitted to two cranks by two connecting-rods. On the cylinder cover the scavenging valves are fixed. Along the circumference of the cylinder walls, ports are arranged for the exit of the burnt gases, together with the scavenging air which expells them. These slots are placed near the outer dead center position of the piston. Three main bearings are necessary. While an expansion takes place in the one cylinder, compression is accomplished

in the other, and *vice versa*. In the upper dead center position the heat supply or fuel injection takes place. In the outer or lower dead center position of the piston the products of combustion are expelled. For every revolution two power strokes are obtained.

Through the action of forces in the cylinders during both the working and compression strokes, a tension is created in the engine frame of varying amount for each cylinder support. In the transmission of the piston force of the one cylinder on the crankshaft during the expansion stroke a vertical downward reaction is set up in the two corresponding main bearings. The same happens in the force transmission from the crankshaft to the piston of the other cylinder during the compression stroke. The inertia forces due to the reciprocating parts augment these loads. Thus during every revolution the three main bearings have to support loads varying in amount.

The strongly fluctuating load to which the foundation is exposed during every revolution excites vibrations in the latter. Special stress should be laid on the large amount of energy efflux necessary for the maintenance of these vibrations. This energy is, of course, lost and detracts from the effective output.

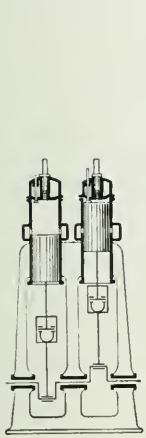


FIG. 37

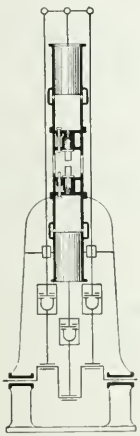


FIG. 38

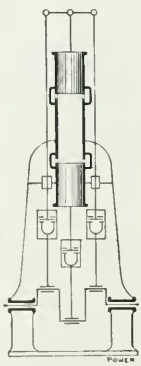


FIG. 39

To attain favorable dynamic conditions the following changes may be resorted to: Two cylinders may be set one above the other, and the transmission of forces arranged as shown in Fig. 38. Then by the medium of three connecting-rods the mechanical energy is transmitted to three cranks. In addition, one traverse piece and two side rods are necessary. The scavenging valves are arranged in the cylinder covers, as in Fig. 37, and the exhaust ports are placed along the circumference of the cylinder, in the outer dead center position. The expansion and compression strokes take place simultaneously in both cylinders, and at the extreme inside position of the pistons, fuel injection takes place, while the burnt gases are expelled in the outer dead center position. For every revolution there is one power stroke as against two in Fig. 37. Assuming both types of engines to have equal diameters of cylinders, equal lengths of stroke and the same number of revolutions, their outputs will be equal.

Provided the forces acting on the cylinder covers are the same they neutralize each other completely. The forces in the engine which severely tax the frame in Fig. 37 are obviated, the acting forces being restricted to the power-transmitting mechanism. As the lower piston is connected to the middle crank its force is divided equally between the two main bearings. The direction of these loads is vertically downward and upward, alternately; the same being true for the two side cranks. Only the forces encountered here are always in opposition to those just mentioned. The main bearings are thus disburdened of any loads that might otherwise exist. A small residual load, however, is retained. For this the obliquity of the connecting-rod is responsible. In the arrangement illustrated in Fig. 38 the coefficient for the fluctuation of speed is twice as large as in the case of Fig. 37. For the same uniformity of twisting moment the former will require a heavier flywheel. But as resulting advantages of the second arrangement, the main bearings are relieved of loads, the forces are balanced in the mechanism instead of the frame, and the inertia is balanced in coincident lines.

Dispensing with the cylinder covers and replacing the two cylinders by a single one, the type shown in Fig. 39 is arrived at. Compared with the type in Fig. 37, this third type possesses the same advantages as the second (Fig. 38). In addition, however, there are the following favorable features: the cylinder covers are obviated and the engine becomes shorter. The scavenging valves are dispensed with, as the row of ports in the cylinder wall are utilized for scavenging purposes, and the scavenging conditions are made more favorable. Finally, the harmful heat dissipating surfaces at dead center are restricted to a minimum. This third type corresponds to the Junkers engine.

CORRESPONDENCE

What Causes the Pound?

We have a three-cylinder 80-hp. Sheffield oil engine direct connected to a 50-kw. alternator. The fuel is 40 deg. distillate, although gasoline is used for starting. Ignition current is supplied from a 110-volt exciter circuit with three 32-volt lamps in series and three groups in parallel (nine lamps) to each cylinder; this furnishes a current of 14½ amp. to the plug.

A pound has developed in one cylinder, occurring at the instant of ignition. Advancing or retarding the spark makes no difference; nor does injecting more water with the fuel. We have tried preheating the fuel, but this does no good. The pound can be stopped by using a richer mixture which, however, reduces the power of the engine. The engine does not pound on light loads.

Can any reader enlighten me as to the probable cause of the pound?

GEORGE E. ABEL.

Ness City, Kan.

⁂

To remove enamel from almost any metal, according to "Revue Produits Chimiques," it is necessary only to heat the enameled object in a furnace or muffle to a red heat and cover the surface with powdered potassium cyanide. After cooling, the enamel will be soluble in water.

REFRIGERATION DEPARTMENT

A Gas Engine Refrigerating Plant

Before the sixth annual meeting of the American Society of Refrigerating Engineers in 1910, R. H. Tait described a refrigerating plant in which a horizontal, two-cylinder, tandem, double-acting, 14x21-in. ammonia compressor, running at 128 r.p.m., was direct driven by a two-cylinder, tandem, double-acting, 21x30-in. gas engine operating on producer gas made from Illinois bituminous coal. The gas producer is of the suction-updraft type, about 10 ft. 2 in. in diameter and 12 ft. high, with 56.75 sq.ft. of grate area.

The general arrangement of the installation is shown in Fig. 1, where *A* is the producer, *B* the uptake open at the bottom to a water-sealed compartment of the hydraulic main *D*, *C* the tower scrubber, containing six water sprays and open to the hydraulic main from which the water is continually overflowing through an 18-in. seal. The water is supplied through the tower scrubber and through four large sprays in the hydraulic main proper. The tar extractor *E*, running about 1350 r.p.m., is direct connected to a 15-hp. motor, while the gas blower *F* is connected to a 10-hp. motor and runs at a speed ranging from 800 to 1600 r.p.m. The gas blower is bypassed into the hydraulic main, which is sealed so as to deliver the required pressure at the engine. The gas main is a 10-in. pipe having a fall toward the blower.

The uptake *B* is a 16-in. vertical pipe resting on a 10-in. pipe open to the water-sealed compartment of the hydraulic main, allowing the deposit of soot to fall into this compartment. This offset from 16 in. to 10 in. provided a shelf on which the soot built up, and the opening through the 16-in. pipe was reduced to the size of the 10-in. pipe, upon which it rested. The horizontal connection between the uptake *B* and the tower scrubber *C*, also filled up, effectually preventing any draft through the producer and shutting off the gas supply to the engine. Upon opening the uptake the gas in the pipe took fire, the soot burned out, the charred mass was removed and to prevent future accumulations, scrapers were inserted which could be used during operation.

The tower scrubber with its six horizontal sprays partially cleans and washes the gas before it enters the hydraulic main, which is a horizontal tank, 4 ft. in diameter, 20 ft. long and made of ⅜-in. iron. The function of the hydraulic main is to reduce the velocity of the gas, thereby allowing impurities to precipitate which are held in suspension at higher velocities. The water supplied is sufficient to carry the greater part of these impurities to the sewer, and the tar accumulation in the bottom is removed about once in two weeks.

At the outset the producer was started on gas-house coke and the fire allowed to build up gradually to heat up the lining. After the heavy firebrick lining was hot, with a proper depth of fuel bed, bituminous coal was fired. It developed that bituminous coal, with the same handling as coke, clinkered and the bed became unmanageable. It was then decided to build up the fuel bed with buckwheat anthracite, then gradually introduce the bituminous coal. Although somewhat more successful, the experiment proved a failure on account of the excessive expenditure of labor necessary to keep the fuel bed in condition to make gas.

It may be well to state here that coke, being light, requires frequent poking down to close the voids or blow-holes in the bed. Anthracite coal tends to pack, offering a more uniform resistance to the draft. This bituminous coal, immediately after charging, is easily spread and acts similar to anthracite, but when once hot it exhibits a marked tendency to run together and clinker if poked.

Consequently the excessive poking was eliminated and the fuel was spread immediately after charging. The fuel bed, however, would burn through at the lining, forming blow-holes. To overcome this difficulty without resorting to poking, ash was allowed to accumulate at the lining, forming a dish-shaped ash bed, varying from 3 to 6 in.

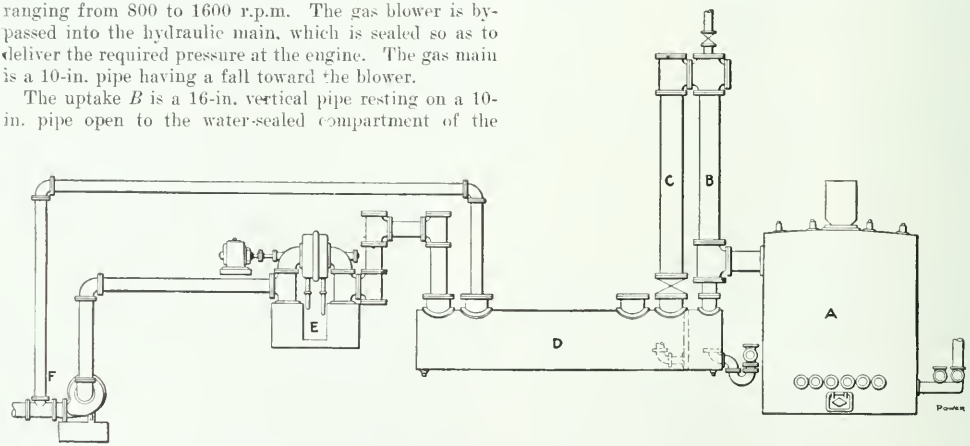


FIG. 1. ARRANGEMENT OF ORIGINAL INSTALLATION

in the center to from 6 to 12 in. at the outer edge. Excessive accumulation of ash was dropped into the ashpit by using short pokers through the side poke holes.

It developed that the deeper the fuel bed the more uniform the quality of the gas. Different depths of bed were tried, ranging from 2 to 6 ft. With the 6-ft. depth of bed, the top of the coal in the center of the producer was above the bottom edge of the petticoat and the coking around this bottom edge prevented the proper spreading of the fuel; hence the bottom edge of the petticoat determined the maximum depth of the fuel bed as 4 ft. The operation resolved itself into charging coal at certain intervals, depending upon the load, spreading the charge immediately after dumping and cleaning out the ash about every eight hours.

Instead of employing a gas tank to furnish a constant supply of gas to the engine, the speed of the blower was varied with the changes in the load and the gas was delivered to the engine at a pressure of about one inch.

Since this paper was presented some changes have been made in the gas-cleaning apparatus to improve operating conditions. These changes were enumerated and the results of tests on the plant were given by E. W. Gallenkamp, Jr., in a paper read before the society at the December meeting. Fig. 2 shows the remodeled plant. The uptake *B* and the tower scrubber have been eliminated and the gas passes directly into the hydraulic main *D*. The tar extractor was placed close to the hydraulic main and the bypass around the blower is now used only in starting the engine. The hydraulic main was cut off at the bottom one-third of the way up, partitioned in the middle and the entire tank water sealed. The partition has a 6-in. hole through which the gas must pass. A flat cast-iron ring about 6 ft. inside and 8 ft. outside diameter was placed upon the grate bars in the gas producer to obviate the formation of holes in the fuel bed at the sides. Scrapers were inserted in the connections between the producer and the hydraulic main.

To obtain the best results with the producer, the coal is spread immediately after charging and must not be disturbed after it becomes hot. If a coke crust overspreads the surface of the bed, preventing a free passage of gas, this crust should be broken up, inserting the poker to not more than 12 in. below the top of the bed. The ashes are drawn once in three hours and every two weeks the machine is shut down for three or four hours to clean the gas-cleaning apparatus and the igniters on the engine.

After the gas leaves the tar extractor it still carries tar in suspension, but is completely purged of soot. The governor valves on the engine show a heavy coating of tar at the end of two weeks, and, in fact, wherever the gas changes its direction or velocity tar is deposited. The tar extractor is the main source of trouble, as a new rotor is required about every five months.

Originally the governor on the engine was connected up for a uniform quality of gas, varying only with the quantity of mixture. The mixture of air and gas was to be regulated by hand. The variable gas quality made it necessary to alter this regulation, so that now the governor varies the mixture. In addition the sensitiveness of the springs in the governor was diminished to reduce the speed variation. When the governor rides near the top, the speed of the engine is about 132 r.p.m., and when riding near the bottom, but still within its range, the speed is about 120 r.p.m., giving an average of about 127 r.p.m. By means of a turnbuckle in the rod from the governor arm to the governor valve shaft, the speed of the engine may be reduced to 80 r.p.m., a reduction of 47 r.p.m. This reduction in speed being effected by wire

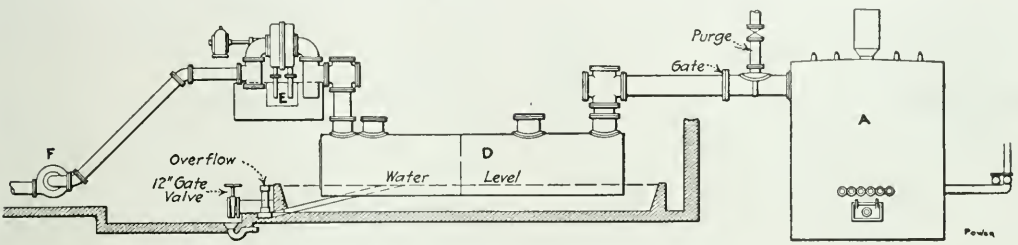


Fig. 2. Plant after Gas-cleaning Apparatus Was Remodeled

drawing of the gas increases the tar deposit and necessitates more frequent cleaning of the valves. Before the application of the turnbuckle on the governor rod, operators frequently reduced the speed of the engine to 30 r.p.m. by throttling at the main gas valve, which resulted in completely filling the 62-in. pipe just in front of the valve with tar.

Test of Plant

The manufacturer of the gas engine and producer guaranteed under normal load a brake horsepower-hour on not more than 1½ lb. of coal of the same grade as that used under the boilers. To demonstrate this, indicator diagrams were taken and the horsepower calculated from the diagrams. After a week's run the engine had developed on an average 318⅓ i.hp., while the compressor indicated horsepower was 222.05, representing a combined mechanical efficiency of 69.7 per cent. It is assumed that the mechanical efficiency is equally divided—that is, 84.85 per cent. for each machine, making about 170 b.hp. for the engine, which is about 75 per cent. normal load. The results show an average consumption of only 1.51 lb. per b.hp.-hr. of washed Illinois bituminous coal, averaging 11,028 B.t.u. per lb.

Starting on Nov. 30, 1911, a six-day test was conducted to determine the number of pounds of ice per ton of coal it was possible to produce under normal operating conditions, which were not ideal by any means. Readings were taken every three hours and the results plotted in charts were presented in the paper.

The condenser pressure was carried at 180-lb. gage and the suction pressure at 17 lb. The temperature of the atmosphere averaged 37 deg. F., the brine in the freezing tanks 15 deg. and the water entering the forecooler 53 deg., where it was cooled to about 35 deg. Out of a nor-

mal capacity of 816 cakes, averaging 405.8 lb., per day, about 600 cakes were pulled daily during the test, except on Sunday, when 352 cakes were pulled in half a day. The total amount was 3425 cakes, amounting to 115.8 tons per day of 24 hr.

In the 144 hr. of the test there were three stops, one for 15 min. and two for 20 min., a total of 55 min., leaving 8585 min. of actual running time. The total number of revolutions as shown by a recorder was 993,076, or an average of 115.68 r.p.m. The cubic-inch displacement per revolution of the compressor is 12,930.96 and per minute would be 1,495,853.45 cu.in.

This means 12,918 cu.in. displacement per minute for a ton of ice per day. The ice tank contains 1632 cans, which makes the rate of freezing per cake about 68⅔ hr. The results of the test are partially summarized in Table 1.

TABLE 1. SUMMARY OF TEST

Duration of test, hr.	144
Total amount of ice pulled, cakes	3,425
Av. wt. of cakes, lb	405.8
Total weight of ice pulled, tons	694 9
Average amount of ice per day, tons	115.8
Total coal consumption, lb.	62,900.0
Total coal consumption, tons	31 45
Av. coal consumption per day, tons	5.24
Total ashes, lb.	6,650 0
Average ashes per day, lb.	1,108 4
Ash in coal, per cent	10 6
Ice per ton of coal, as fired, tons	22.10

The power consumed by auxiliaries is estimated as accurately as possible in Table 2.

TABLE 2. POWER CONSUMED BY AUXILIARIES

	Horsepower
Driving ice-tank agitators	21.24
Driving tar extractor and igniter generator	17 41
Circulating jacket cooling water	3.13
Circulating oil in lubricating system	0 25
Pumping water for condenser and cooling coils	9 51
Pumping distilled water	1.15
Furnishing compressed air for hoisting and starting	5.75
Total	58 44

Assuming 1.81 lb. of coal per horsepower-hour, including an allowance for transmission from engine to motor, would give a coal consumption for auxiliaries of

$$58.44 \times 1.81 = 2540 \text{ lb.} = 1.275 \text{ tons per day}$$

Including auxiliaries, the total coal consumption on the above assumptions would be 5.25 tons plus 1.27 tons, or 6.52 tons per day. The ice per ton of coal as fired would then be:

$$115.8 \div 6.52 = 17.8 \text{ tons}$$

Summer conditions would call for more water on the ammonia condenser, as the temperature of the water at that season is often as high as 88 deg. F., and the temperature of distilled water to the forecooler as high as 96 deg. F. The temperature of the atmosphere would average for the hot months about 79 deg.

The cooling water from the ammonia condenser is used in the gas-cleaning apparatus and is ample for the purpose, but the tar and impurities taken up make the water unfit for use in a cooling tower. Where water is obtained under difficulties and at a considerable cost, a plant of this arrangement would be prohibitive. With the exception of the tar extractor, the installation has given good service throughout the summer. The shutdowns, as shown on the record for 183 days, from Apr. 1 to Oct. 1, 1912, are given in Table 3.

TABLE 3. SHUTDOWNS IN 183 DAYS

	Hours	Minutes
Due to tar extractor	51	25
Fourteen Sundays	49	..
Due to producer, engine or compressor	32	5
Total	132	30

Physical Properties of Ammonia

In a paper read before the American Society of Refrigerating Engineers, Prof. Lionel S. Marks and F. W. Loomis, of Harvard University, gave the results of the most important experimental work published so far, some analysis of those results on thermodynamic and other grounds, and a critical discussion of the tables that have been prepared by various authorities.

In conclusion it was agreed that the best table of the properties of saturated ammonia is that given by Wobsa in his second paper. This table transformed into English units, is given herewith, but should not be confused with the earlier table by the same authority. The present state of knowledge of the properties of ammonia is much more satisfactory than it was ten years ago, and the accompanying table may be used for ordinary engineering calculations with some confidence.

For greater accuracy, it is necessary that the specific heat of the liquid ammonia should be further investigated and that confirmatory data should be obtained on specific volumes of the saturated and superheated vapor. The vapor pressure needs some further determinations at low temperatures, but it is probably known with sufficient accuracy throughout the range used in engineering practice.

In another paper on the same subject, William E. Mosher presented an interesting discussion on former experimental data and proposed several formulas to express the various properties of ammonia. The values resulting from the use of these formulas agree closely with experimental data and by Mr. Mosher are considered more accurate than the values given by Wobsa, although the difference between the two sets of data is not very great. No working tables of the properties of ammonia were included in the paper, but such tables have been prepared for both the saturated and superheated vapor and they will appear shortly, together with a Mollier diagram for ammonia, in a bulletin of the engineering experiment station of the University of Illinois.

TABLE OF THE PROPERTIES OF SATURATED AMMONIA VAPOR, BASED ON WOBSA'S SECOND EQUATION (1908).

Temperature Deg. F.	Pressure, lb. per sq.in.	Specific Volume, cu.ft. per lb.	Density, lb. per cu.ft.	Heat of the Liquid B.t.u.	Total Heat, B.t.u.	Latent Heat. B.t.u. Total	Internal	External	Liquid n.	Entropy. Vapor N.	Difference $N-n$.
—22	16 98	15 80	0 06329	—58 91	524 9	583.7	534 2	49 50	—0 1265	1.2090	1.3355
—13	21 58	12 60	0 07936	—49 32	528.1	577.4	527.2	50.18	—0 1048	1.1891	1.2939
—4	27.14	10.13	0 09871	—39 65	531.0	570 6	519.8	50.78	—0 0835	1.1699	1.2534
+5	33 81	8 323	0.1201	—29 90	533 9	563.7	512 3	51.34	—0 0622	1.1524	1.2146
14	41 69	6 744	0.1483	—20 04	536 2	556.2	504.4	51 84	—0 0414	1.1351	1.1765
23	50 95	5.569	0.1796	—10 06	538 6	548 6	496.4	52 23	—0 0206	1.1174	1 1370
32	61 71	4 635	0.2157	0	540 7	540.7	488 0	52 63	0.	1.1011	1.1011
41	74 21	3 885	0.2574	10 17	542 5	532.5	479 5	52.97	0 0205	1 0852	1.0647
50	88 55	3 275	0.3053	20 45	544 0	523 6	470.3	53.22	0.0405	1.0690	1 0285
59	104 90	2 776	0.3602	30.83	545.2	514 5	461.2	53.39	0 0607	1 0540	0.9933
68	123 5	2 366	0.4227	41.31	546.3	505.1	451.6	53 50	0.0805	1.0392	0 9587
77	144 4	2.027	0.4933	51 91	547 0	495.2	441 7	53 50	0.1003	1 0245	0 9232
86	168.1	1 745	0.5730	62.55	547.4	484 9	431.4	53.42	0 1197	1.0102	0.8905
95	194.5	1 509	0 6627	73 42	547 7	474.3	421 0	53.33	0.1392	0 9963	0.8571
104	224 0	1 309	0 7640	84.37	547.7	463.3	410.2	53.10	0.1584	0.9826	0.8242

EDITORIALS

Surface Condensation

It is always a bit difficult to grasp the significance of any discussion relating to molecules. We cannot see nor feel a single molecule and, if we hadn't more faith than the farmer at the circus who would not believe there was such an animal even when he saw the giraffe, we would refuse to believe that anything so small as a molecule can exist. To comprehend the actions of these infinitesimal particles it is helpful to consider them magnified to the size of some familiar object as a billiard ball or a ball of putty, as Professor Munro has done in his analogy for initial condensation on page 128.

For simplicity's sake he has taken other license with the molecules than simply to enlarge them, giving them difference of hardness, whereas we have been taught to believe that the simon pure molecule is unyielding and incompressible. He has also overlooked the fact that when the steam molecules become billiard-ball size the iron molecules of the cylinder walls do also and the surface impinged against is not smooth and continuous.

Instead of impact and rebound of the steam molecules taking place, it is supposed in reality that these molecules have a planetary motion around the molecules nearest the surface of the iron and then return on their course, or remain in the same neighborhood with the iron molecules. The latter is the phenomenon of initial condensation. The steam molecules lose sufficient velocity (or heat) to the cooler and much less active iron molecules in raising the velocity (or heat) of the latter for the steam to condense to water.

Although the hypercritical may discover these weak spots in Professor Munro's analogy, we believe he was justified in taking the liberties he did and rather like his simple explanation of initial condensation.

What Is a Horsepower?

A horsepower equals 33,000 foot-pounds per minute, or 550 foot-pounds per second.

What is a foot-pound?

The amount of energy necessary to overcome a pound of resistance through a foot of space, as when a pound weight is lifted one foot, or a pressure of one pound is exerted upon a body (as, for instance, a piston) to move it through one foot.

What is a foot?

By an Act of Congress, July 28, 1866, the meter, which contrary to the general impression, is the fundamental standard of length in the United States, was declared to be equivalent to 39.37 in. The legal foot in the United States is therefore 0.304801 of a meter. The international meter is the length of a bar of platinum and iridium preserved at the International Bureau of Weights and Measures near Paris. The United States owns two duplicates of this bar.

There is, therefore, a standard fixed value for the foot, so far as the United States is concerned.

What is a pound?

The pound is defined in terms of the kilogram as the foot is defined in terms of the meter. For purposes of discussion we may consider that there is at Washington a standard piece of metal, the weight of which is one pound.

What do we mean by weight? Ah, there's the rub.

Weight is the measure of the force of gravity upon a body. If this standard pound weight is put into one of the pans of a pair of balances and enough of some other material is put into the other pan to balance it, the amount of matter so measured is a pound, because the earth pulls upon it with the same force that it does upon the standard pound weight.

But the pull of the earth, the attraction of gravitation, is different at different parts of the earth. At the equator it is partly neutralized by the centrifugal force, due to the earth's rotation upon its axis, and the greater distance from the earth's center of gravity. The same thing applies to elevation above the sea level, so that the force with which the earth attracts this pound weight varies with latitude and elevation.

If the scale with the standard pound weight in one pan and the mass of some other material which will balance it is taken to the poles or to the equator it will still balance, because the lesser or greater force exerted by the earth will be exerted upon the two bodies alike. Determined in this way "a pound is a pound the world around," a mass equal to that of the standard pound weight.

Suppose, however, the standard pound weight to be hung upon a spring scale at the latitude of Paris, and a mark to be made opposite the pointer indicating one pound. If this spring scale, so weighted, be taken to the equator the pointer will stand above the mark which was made at Paris, on account of the lesser attraction of the earth upon the weight, and it would take a greater amount of matter to indicate a pound upon this kind of a scale at the equator than further north, if the matter upon which the earth will exert the force necessary to stretch the spring until the pointer reaches the mark made in Paris be accepted as the pound.

Take a mass of 55 pounds. It would balance 55 of the standard weights anywhere in the world, but it would take a greater force to lift it at Berlin or London than it would at Havana or New Orleans. If it is lifted ten feet in a second, work is done at the rate of one horsepower according to the above definition, but there has not been so much energy used at the southern as at the northern latitudes.

Is the horsepower then an indefinite variable quantity, varying with latitude and elevation?

The U. S. Bureau of Standards says that it is, and recommends that it be given stability by being considered as equivalent to 746 watts, which would be 550 foot-pounds per second at about the latitude of London and sea level.

It is an absolute unit only if there is as absolute a

definition of the pound as there is of the foot; and if the pound is a measure of force as well as of mass.

There is such an absolute definition in common use. It is the force with which gravity attracts the standard pound weight at 45 degrees latitude and at sea level, the force which acting constantly will accelerate that pound of mass at the rate of 32.174 feet per second.

Having thus an absolute unit of force and of space the absolute value of the foot-pound is fixed, and 550 of these foot-pounds per second is just as absolute a value for a unit of power as the watt.

The values of the horsepower and the watt are thus absolutely fixed and the horsepower is equal to 745.7 watts. The only way to make it equivalent to 746 watts without changing the value of the watt is to change the value of the horsepower. This involves either using 550.22+ foot-pounds per second, 33,013.2+ foot-pounds per minute as the horsepower or changing the accepted value of the pound. Nobody would countenance the changing of the horsepower to this inconvenient and incomplete number of foot-pounds, and the changing of the value of the pound is too serious a matter to consider for the purpose simply of being able to express horsepowers in even figures in terms of watts.

Unless this is done the best we can do is to recognize that a horsepower is 745.7 watts and use the 746 as the nearest round number as we do 778 as the mechanical equivalent of the heat unit in calculations which do not involve the greater degree of accuracy. This is the value given in the conversion table accompanying the Marks-Davis steam tables, and that arrived at in Mr. Kent's consideration of the subject on page 109 of this issue.

The Commercial Engineer

Representatives of water, electric-light and other public-service corporations, in defense of their rates invariably put stress upon the fact that it is service they are selling. They must maintain a great organization of skilled specialists and a great aggregation of plant and apparatus so that when one turns the cock water will come, or when one wishes light that there shall be light.

Carrying the thought a little further, when a man sells an engine he does not sell merely so much steel and cast iron; nor merely the combination of those materials with the work of the foundryman and the machinist, who have fashioned and fitted it. If the salesman is a commercial engineer in the highest significance of the term he sells a solution of his customer's trouble and a fulfillment of the needs and purposes in his particular line. He is able to do this because he is a specialist in that line. He knows what is available; what its capacity, capabilities and limitations are, and if he is disinterested and knows the engineering end of his line as well as he does his discount list and the commission rates, he is the best adviser that an intending purchaser can possibly have.

But when one holds a brief for a particular line, and when one's income depends on the amount of his current sales, it is not easy to be disinterested.

Here is a textile concern, say a carpet mill, that can use up all the exhaust steam it can make. The manager writes to a builder of condensers that he is in the market for a large order. Will that condenser salesman go there and tell that man that he has no need for a condenser, or will he try to close him for the biggest order that he can land? Will he approach that job as an engineer or as a condenser salesman?

Is his success measured by the soundness of the engineering advice that he gives (for nothing when it does not lead to business) or by the dollar's worth of orders that he sends in?

The concern which adopts the altruistic attitude will acquire a great standing in the course of time. If the carpet maker ever did need a condenser or had anything to say about the buying of one there is only one place to which he would naturally look and one man to whom he would first turn for advice; but how far, from a business and commercial point of view, can a concern go in the direction of maintaining a corps of specially trained men to travel at its expense and advise people not to buy its goods?

There is no doubt that the manufacturer is often imposed upon with respect to engineering service and advice. Recently bids were invited for an installation in which each bidder was required to submit plans and specifications of his outfit, and when they were all in, the consulting engineer of the purchaser simply made up from the symposium an excellent layout embodying the best suggestions of all the contestants and had it built himself.

But if the selling representative is to be simply a salesman, why the term "commercial engineer?"

The title is suggestive of an intelligent effort to apply real engineering to the disposition and application of engineering devices and appliances, and to remove from commercialism, as applied to engineers, some of the opprobriousness which has resulted from abuses committed in its name.

It is for those who have adopted the title commercial engineer to emphasize the newer and better meaning of the term; to demonstrate that in the selling of engineering apparatus and materials, real engineering knowledge of the merits, capabilities, yes, and limitations of one's wares and ability to meet the engineer users of those wares upon a common plane of mutual engineering interest are worth more than lung power or eloquence.

These Lawyers!

For real comedy what can equal the outcome when a smart lawyer tries to heckle the expert witness and gets the worst of it—as usual? Up in New England a few days ago, as related in the letter on page 128 entitled "Engineers' License Law Violation," the defendants' lawyer could not understand why a first-class licensed engineer should be worth forty dollars a week. To him an engineer is a part of the great dinner pail and overall fraternity; he does not sense it that knowledge and judgment are as essential to the successful handling of a power plant as to anything with which he has to do. Nor could he appreciate why one plant may require a higher salaried man than any other. It is the old, old story of the futility of trying to make the legally-trained mind grasp the most elementary principles of other professions. This is no reflection on lawyers as a class, for they should not be and are not expected to know everything about all vocations. The pity of it is that they feel that their success depends on their assuming the all-wise air; otherwise they would save themselves many embarrassing predicaments.

READERS WITH SOMETHING TO SAY

Operating Costs of Hydraulic vs. Electric Elevators

It is not often that the operating engineer has an opportunity to determine or get acquainted with the cost of operating an electric and a hydraulic elevator for the same building and kind of work. I was fortunate enough at one time to operate a plant where electric elevators were substituted for the hydraulic ones then in service. This plant consisted of five 72-in. horizontal return-tubular boilers and twelve electro-magnet-control hydraulic elevators, running 450 ft. per min. The building was a 12-story office structure. This plant supplied steam and hydraulic power to three office buildings of this kind.

The pressure tank was badly pitted and later condemned by the inspector. I recommended the purchase of a new pressure tank, as this was the only part of the equipment that was crippled. Other influence was brought to bear, however, and the management decided to take out the hydraulic elevators and install electric machines. This called for an expenditure of over $13,000.

These buildings were using central-station current when the hydraulic elevators were in service. The exhaust steam from the elevator pumps was sufficient to heat the building, giving a back pressure of nearly 2 lb. in the coldest weather. Live steam was very seldom used.

I kept records of the coal consumption for one year and compared those covering the same summer months, while the hydraulic elevators were used, to those covering the same months when the electric elevators were in service. I found that the coal consumption had decreased 24 tons per month over the year previous, with other conditions practically the same. It must be remembered that no steam was being used for heating purposes during these months and that the decreased coal consumption of 24 tons represents quite accurately the saving made by the electric elevators. But as soon as the buildings had to be heated, instead of using exhaust steam as in the year previous, it was necessary to use live steam at about 2-lb. pressure, through a reducing valve.

Records of the coal consumption for the winter months show that 20 tons more per month were required when the electric elevators were used over that necessary when the hydraulic elevators were in service. This average increase of 20 tons per month continued year after year. It must be remembered that the cost of the current for the electric elevators must still be added to the coal bill, because during previous years this coal consumption was that incurred by running the elevators and furnishing the buildings with heat, whereas with the electric elevator the coal consumption increased and still the cost of the current had to be added to the coal bill. I have records of the kilowatt-hour consumption, but as the reading includes lighting and motor current, all on the same meter, the current used by the elevators could not accurately be estimated.

Had it not been that the space formerly occupied by the hydraulic elevators had been rented there would have been a considerable loss, due to the change in elevator service.

On the whole, electric elevators are to be preferred over hydraulic ones, because there are very few accidents that can be traced to this type of machine. They are quickly stopped and started, and never safer than when stopped, for when the lever is central or the main switch is pulled, the brake spring grips the brake and will not allow any movement of the car. This is entirely different with the hydraulic types, as they are never more unsafe than when they are stopped; one cannot tell at what instant they will start to creep up or down when the lever is central. This is due to leakage of the pilot valve or the cup leathers in the main valve, which allows water under pressure to be admitted to the plunger cylinder and thereby start the car. Numerous accidents have been caused by this creeping, as operators frequently leave the car, and when they return after a few minutes' absence they find it creeping up and try to get aboard it, and in so doing are caught between the car and the floor.

Pilot valves often become plugged in the ports with packing fiber, and this trouble makes it impossible to hold the car in one position for more than a minute or so. If the pilot and main valves are in perfect condition the car will stand for any length of time if the lever is central; but on account of the continual wear they are subject to, it is seldom that one finds these valves to be perfectly tight.

There are a number of electric elevators in this city, but I cannot recall one accident to them or to their operators. It would be interesting to read statistical reports of accidents to hydraulic and electric elevators respectively.

A. C. WALDRON.

Revere, Mass.

Low Pressure Turbine Experience

Several years ago while in charge of a power house in southern Maryland, I had a peculiar experience with a 750-kw. low-pressure turbine. The turbine was set to run at 7-lb. pressure, but had a connection for high pressure (150 lb.), which would open automatically in case of a shortage of low-pressure steam. We had considerable trouble with the turbine because it took high-pressure steam at all times, and carried small loads as well as heavy ones. This waste of steam made much difference in the coal bills and it became necessary to remedy the trouble, due to this increasing expense.

The turbine received its low-pressure steam from three engines exhausting into a receiver and these through a separator into the turbine. This separator was of the vertical type about 7 ft. high and 3 ft. in diameter, and as there was not room to spare, it was set down under the floor and extended into the ground. We took the turbine

apart and found all the blades in good condition, except that they were covered by a thin coating of magnesia, and it was thought that this may have made some difference in the steam consumption, but after running the turbine a few weeks we again experienced the same trouble.

Several weeks later a copper expansion joint between the separator and the turbine sprung a leak and as we had to tear the concrete floor up to get at it, I decided to examine the separator. After removing the top plate, we found that it contained a large screen made of sheet steel punched full of holes, and over each hole there was a piece of steel that acted as a shield. These holes were completely stopped up with what we took to be soft packing that had worked through from the engines. After thoroughly cleaning this out, which took about two days, we put the separator together again. We also lost no time in putting brass rings in back of each piston-rod stuffing-box to keep the packing where it belongs. This undoubtedly prevented the packing from being drawn into the separator as no trouble from plugged screens was again experienced, and the coal consumption immediately decreased.

PAUL B. PRUTZMAN.

North Wales, Penn.

Engineers' License Law Violation

There was a case in court in this district for violation of the engineers' license law. The defendants were represented by a lawyer, while the state inspector conducted the case for the Commonwealth.

It came out at the trial that the defendants were operating a first-class plant with a special license, which was issued for the operation of the old engine. In the meantime they had installed a steam turbine having a steam inlet of such size that the law called for an operator with a first-class engineers' license.

They claimed that they could not find a first-class man; that they had advertised in all the local papers without results. At this stage of the procedure the inspector said that he could and would furnish the defendants with a first-class engineer capable of taking charge of their plant.

After a whispered conference between defendants and lawyer, the lawyer asked:

"How much a week would such a man expect?"

Inspector: "About forty dollars."

Lawyer: "Now, Mr. Inspector, don't you consider $40 per week pretty steep for an engineer?"

Inspector: "No I don't. Do you consider yourself worth that amount per week?"

Lawyer: "Yes, but what has that got to do with this case?"

Inspector: "Only this, a man who gets a first-class engineers' license in this state has to study longer, and, in fact, know more than you do."

Lawyer: "Are you in the business of furnishing first-class engineers?"

Inspector: "No."

Lawyer: "Have you ever furnished a first-class engineer to any firm in this locality?"

Inspector: "Yes, one. This firm's superintendent claimed he could not get such a man, and I found one for him at his request."

Lawyer: "How much did this man get per week?"

Inspector: "Thirty dollars."

Lawyer: "Then why do you say that my clients would have to pay $40 per week?"

Inspector: "Because of the difference in the operation of the plants."

Lawyer: "Would you mind explaining what the difference is?"

Inspector: "No, I would not mind, but what is the use, you would not understand if I did."

JOHN ARMSTRONG.

Adams, Mass.

How Should New Valve Stems Be Put?

In the near future I must put in a new set of valve stems in our Corliss engine. As I have never before put in a set of valve stems I would like to receive full directions for doing this work from some reader who has had such experience. Will it be necessary to so disturb the adjustments to the valve gear as to require the valves to be reset after the new stems have been put in? Keyways must be cut in these new stems before they are put in.

H. W. LEE.

Lynchburg, Va.

[Ordinarily all that should be necessary is to cut the keyseats in the new valve stems in the same place that they are located in the old stems. The new stems could then be put in without disturbing the adjustment of the valve gear.

Perhaps some reader will comment.—EDITOR.]

Analogy for Initial Condensation

It is well known that one of the principal sources of loss in a steam engine is that due to initial condensation, or heat lost from the steam as it condenses on the comparatively cool cylinder walls on entering the engine. This loss or heat interchange between the steam and the cylinder can be greatly reduced by using superheated steam and to understand why this should be so, perhaps the following rather crude illustration will prove of assistance.

Imagine yourself equipped with a thousand ivory billiard balls at 100 deg. F., which you throw against a piece of armor plate at 60 deg. F. The perfectly elastic balls bound away so quickly that they give little of their heat to the plate, which remains nearly stationary in temperature. Now change a half of the balls for soft putty balls of the same size and temperature. Instantly a putty ball hits the iron it flattens out and sticks, giving up all its available heat to the iron surface.

The ivory balls represent molecules of superheated steam in such a stable condition that they are able to withstand impact against a colder surface without losing their shape or elasticity. The putty balls, on the other hand, correspond to steam molecules, which collapse or condense, on striking the iron to which they give their heat on condensation.

G. W. MUNRO.

LaFayette, Ind.

The 22,000-b.hp. Zoelly turbine, which is being built for the Manchester (England) Corporation power station, will have only 14 stages as compared with 20 stages in the previous 6000-kw. sets.

QUESTIONS BEFORE THE HOUSE

Piston Rod Area in Horsepower Calculations

In the reply to J. N., in the Nov. 12 issue (Inquiries of General Interest), relative to neglecting the area of the piston rod in calculating the horsepower of an engine, I note that you say that "for all practical purposes it may be neglected, but to be accurate it should always be considered."

Your reply recalls the method used by one firm in calculating the horsepower from the diagrams. It consists simply of subtracting one-half the area of the piston rod from the area of the piston. It will be seen that as on one side of the piston we have no piston rod and on the other we have the piston-rod area, this process balances the areas.

To take an example from practice: In a certain marine engine the high-pressure cylinder diameter is 31 in., stroke 5 ft. 6 in. and the diameter of the piston rod $6\frac{1}{4}$ in. On one run the mean effective pressure, as shown by the indicator diagrams, was 51.6 lb. and the revolutions per minute 50. Now neglecting the area of the piston rod we have

Area of cylinder = 754.77 sq.in.

Cylinder constant equals

$$\frac{2\,LA}{33{,}000} = \frac{2 \times 5.5 \times 754.77}{33{,}000} = 0.2516$$

$$i.hp. = (51.6 \times 0.2516) \times 50 = 649.1$$

Again considering the area of the piston rod we have, area of cylinder — ½ area of piston rod is

$$754.77 - 15.33 = 739.4\ sq.in.$$

Cylinder constant

$$\frac{2 \times 5.5 \times 739.4}{33{,}000} = 0.2465$$

$$i.hp. = (51.6 \times 0.2465) \times 50 = 636\ i.hp.$$

This shows that an error of 2.06 per cent. too much is made when the area of the rod is not deducted from the area of the crank side of the piston. This result, however, is only 0.7 per cent. lower than that given in your answer to J. N.

J. H. George Morrison.

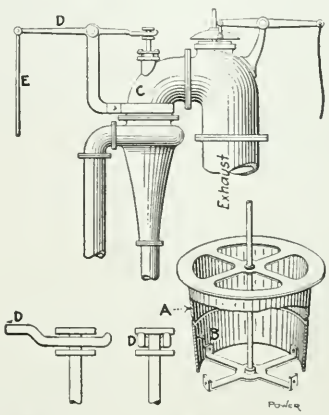
Glasgow, Scotland.

Improvement to Old Style Siphon Condenser

Relative to the article headed "Common Troubles of Siphon Condensers," page 615 of the Oct. 22 issue, the following description of an improvement that greatly facilitates cleaning the condenser cone during the operation of the condenser may be of interest.

The brass cone was removed from the condenser head and cut in the middle. The upper half *A*, was turned down in a lathe and a cut taken off the inside at the top of *B*. This allowed *B* to freely slip over the outside of *A*. A cast-steel spider was made to fit the bottom of *B* and was held by screws. A ¾-in. steel rod was passed through the center of the spider in *A*, as shown. By drilling a hole in the elbow *C*, and fitting a stuffing-box where the eye-bolt was located, the lower half of the cone could be raised while the pump was running and all obstructions washed down into the water-leg.

A lever *D* forked to take in the ¾-in. rod, that had collars above and below the fork, served to raise and



Siphon Condenser Cone Remodeled to Facilitate Quick Cleaning

lower *B*, and a piece of pipe *E* on the other end of the lever enabled one to work the lever from the floor.

This arrangement has worked for about a year without causing any trouble. The saving in labor and gaskets is well worth the trouble of altering the condenser to make the improvement.

E. B. Tifft.

Windsor Locks, Conn.

Removal of Scale from Turbines

In reply to Mr. Wood, who requested information in the Dec. 31 issue as to particulars of our way of removing scale from a turbine, I would advise as follows:

At the present time we are operating 65,000 kw. in units as follows: Three 8000-kw., one 12,000-kw., one 14,000-kw., and one 15,000-kw. unit; all are vertical turbines except one 8000-kw. reciprocating engine. Our boilers are all B. & W. water-tube type equipped with superheaters and fired by underfeed mechanical stokers using forced draft. The boilers have a rated normal capacity of 1000 kw. with two to three inches of water on the draft gage; they carry 180 lb. steam pressure with about 75 deg. F. superheat and the steam is delivered at 170 to 175 lb. with about 25 deg. F. superheat at the throttle. The condensers, with but one exception, are of the counter-current type equipped with displacement rotary pumps.

Our accumulator pressure is 1000 lb. per sq.in., which gives about 750 lb. at full load on the step bearings; this is allowed to approach within 100 to 150 lb. of the accumulator pressure before any cleaning off of scale on the turbine vanes is attempted, as we consider 100 lb. difference a reasonably safe limit.

The maximum quantity of coal oil used in this cleaning is six barrels for a 15,000-kw. turbine, the quantity varying with the size of the machine and the judgment of the engineer in charge as to the amount of scale present as indicated by the step pressure gage and also by the time elapsed since the last cleaning. While this cleaning is being done the turbine is allowed to exhaust straight to the atmosphere through the high-pressure relief valve at the condenser base, thus cutting out the condenser altogether. No appreciable heating of the turbine itself is experienced.

The feed water used is from the Schuylkill River, which, under normal conditions, gives the following analysis, subject to more or less change, due to high or low water, spring freshets, etc.:

PARTS PER MILLION	
Organic and volatile matter	30.3
Inorganic residue	186.3
Total solids	216.6

Further subdivided as follows:

PARTS PER MILLION	
Sodium chloride	19.86
Sodium sulphate	50.95
Calcium sulphate	36.57
Calcium carbonate	46.63
Magnesium carbonate	57.69
Silica, alumina, ferric oxide, potassium chloride, etc.	4.90
	216.60

To make this a good boiler feed water, certain chemicals, such as soda ash, caustic soda, etc., must be added in moderate quantities. A certain amount of "Kutch" is also sometimes used to obtain the amount of tannic acid that will keep the scale from adhering to the tube.

I trust this information will be of benefit to Mr. Wood and others who are troubled with scale in turbines.

MORGAN G. JOHNS.

Philadelphia, Penn.

Design of Surface Condensers

I agree with the general principle of the design of surface condensers as advocated by Mr. Booth in the Oct. 22 issue, if this is not carried to extremes. This is undoubtedly the opinion of all other condenser designers.

Mr. Booth is apparently writing from an idealistic standpoint, but he wisely qualifies his statements to some extent by the following sentence: "Except for considerations of cost and space, there is no reason why a condenser should not be many times its ordinary cubical capacity with widely spaced tubes dispersed throughout the space."

The second of the reasons quoted would appear to be of greater importance, but I would suggest that there is at present no known reason why the cubical capacity should attain the dimensions suggested. In fact, the general tendency today is for surface and volumetric capacity to be reduced rather than increased as a result of more careful design, enabling much higher heat-transmission rates to be adopted.

Undoubtedly the cost has considerable bearing on the proportions of surface condensers, but the mere increase of volumetric capacity may be easily obtained by retaining what is practically the standard width or diameter, and increasing the length of the shell at relatively little additional cost. The major expense in a surface condenser is that due to the tubes and tube plates, and by increasing the length of the shell to obtain greater volumetric capacity only the additional length of tubes would have to be considered.

This arrangement would give an opportunity to increase the tube pitch as recommended by Mr. Booth, but there is undoubtedly a limit beyond which the pitch should not be increased.

One of the principal factors in efficient heat transmission and condensation is a lively molecular motion of the condensing medium and the steam. This fact is generally recognized and acted upon by most of the well known manufacturers of condensing plants.

The important point to bear in mind when proportioning condensers is not so much volumetric capacity as the provision of a perfectly free steam entry to the first and immediately adjacent rows of tubes. Consideration of this statement will show that not only must the tube pitch be carefully proportioned, but the ratio of the length of the shell to the diameter or width, as related to the exhaust-steam inlet branch, must be considered. The exhaust inlet should preferably be arranged so as practically to conform to the shape and dimensions of the condenser top. This is, however, fully recognized as an expensive and awkward arrangement when the space usually provided for condensing apparatus is considered; so the next thing to do is to arrange the exhaust branch on a dome of suitable area in the middle, gradually tapering away to the ends and sides of the shell, thus distributing the steam over the whole inlet surface without the aid of internal baffles.

Practically all manufacturers of standing carefully proportion the pitch of the tubes to provide sufficient steam area based on velocities determined by experiment and depending upon the quantity of steam flowing and the vacuum to be maintained. Steam baffles are now reduced to a minimum; in fact, one manufacturer at least provides only one baffle, and this is in the condenser base.

I have met with condensers wherefrom the removal of certain tubes has proved advantageous, but these have been of the old-fashioned marine box-of-tubes condensers, but I have yet to see a modern surface condenser under proper operating conditions having a difference in vacuum equal to 1 in. Hg. between the inlet and outlet.

The following particulars from actual condensers built by different firms indicate the lines on which they work:

(1) 29.1-in. vacuum; 30-in. barometer. Exhaust-steam inlet velocity 530 ft. per sec., steam velocity between first row of tubes, 250 ft. per sec. In this condenser three tube pitches are used, i.e., 1¼, 1⅛ and 1$\frac{1}{16}$ in. for ¾-in. diameter tubes.

(2) 28-in. vacuum; 30-in. barometer. Exhaust-steam inlet velocity 260 ft. per sec., steam velocity between first row of tubes, 140 ft. per sec. In this condenser two tube pitches are used, i.e., 1⅛ and 1$\frac{1}{16}$ in. for ¾-in. diameter tubes.

Both the above condensers are highly efficient in operation, the circulating water leaving the condenser at a temperature 3 to 4 deg. F. below that of saturated steam at the vacuum carried.

W. VINCENT TREEBY.

Goodmayes, Eng.

INQUIRIES OF GENERAL INTEREST

Polarity of Dynamo—In a dynamo, what determines whether a pole should be N or S, and how may the poles be reversed?

R. G. M.

The polarity is determined by the direction in which the field current flows around the magnet and the poles may be reversed by reversing the direction of the current.

Determining Flow of Water Through Pipe—What is a plain and easily understood formula for determining the amount of water which will flow through a pipe?

S. D. G.

There is no simple formula for figuring this flow. No formula can be absolutely accurate as the rough pipe surfaces are extremely variable, due to the different makes of new pipe, rough interior surfaces and reduction in interior surface diameter resulting from use. Many engineers prefer Darcy's formula, which is

$$h = \frac{(0.0198920 + 0.00166573)\frac{l}{d}}{a} \times \frac{v_2}{2g}$$

in which

h = The loss of head in feet due to friction.
d = The internal diameter of pipe,
v = The velocity in feet per second.
l = The length of pipe in feet.
2g = 64.324.

Illuminating Gas for Heating Purposes—What are the advantages and disadvantages of illuminating gas compared with coal for making steam to heat a small plant that requires 1000 sq.ft. of radiation?

W. T.

Gas burned under the boilers instead of coal would require very little attention after starting the fire. It is cleaner than coal, and if properly introduced into the furnace would produce no smoke. Besides, there would be no standby losses such as banking a coal fire, for the minute the service was no longer needed it could be shut off immediately and started again just as readily. The principal objection to illuminating gas for this purpose is its excessive cost when compared to coal. Ordinarily, a cubic foot of illuminating gas contains about 650 B.t.u. A good quality of coal will contain 14,000 B.t.u. per lb., so that in heat units a pound of coal is equivalent to

$$\frac{14,000}{650} = 21 \text{ cu.ft. of gas}$$

Gas, however, will burn at a little higher efficiency than coal and there will be no standby losses. It may therefore be aasumed that the efficiency of combustion is 10 per cent. higher than that for coal. In reality, 19 cu.ft. of gas will be equivalent to 1 lb. of coal. Multiplying by 2000 will give 38,000 cu.ft. of gas as the equivalent of a ton of coal. A fair price for illuminating gas is 80c. per thousand cubic feet, so that 38,000 cu.ft. would cost approximately $30, as compared to $4 or $5 for a good grade of coal. The excessive cost of the gas would thus eliminate its use.

Waste in Excess Condensing Water—How much money is wasted in a year where such an excess of condensing water in the vacuum pump is required that the feedwater heater constantly overflows at a rate of about one gallon a minute of water that has been heated from 62 to 200 deg. F., if this waste lasts 18 hr. a day and six months in the year, and coal costs $2.90 a ton?

E. T. B.

As the total time is

182½ days × 18 hr. × 60 min. = 197,100 min.

with the discharge rate of condensing water 1 gal. per min., a gallon of water being 8¼ lb., the total weight of heated water lost would be

197,100 × 8¼ = 1,642,500 lb.

Each pound of water being heated from 62 to 200 deg. F. would receive

200 − 62 = 138 heat units

and the total heat lost would be

1,642,500 × 138 = 226,665,000 B.t.u.

From one pound of good coal and 75 per cent. boiler efficiency may be realized about 10,500 heat units. Therefore,

$$\frac{226,665,000}{10,500} = 21,587 \text{ lb.}$$

of coal would be required; that is,

$$\frac{21,587}{2000} = 10.79 \text{ tons}$$

of 2000 lb., which at $2.90 per ton would amount to $31.29.

Calculating Horsepower Without Indicator—What will be the maximum indicated horsepower developed by an engine with 20-in. cylinder, 36-in. stroke, receiving steam at 125 lb. pressure, cutting off at ¼ stroke, exhausting to the atmosphere and running at 90 r.p.m. Also when running at 110 r.p.m.?

F. P. L.

First find the mean effective pressure. This will be the difference between the mean forward pressure and the mean back pressure. The mean forward pressure can be found in Low's "Steam Engine Indicator," page 115, or by calculation from the formula

$$P_m = (1 + \log_e R)(f + c) - c$$

where

P_m = Mean forward pressure per pound of initial pressure
$\log_e R$ = Hyperbolic logarithm of the ratio of expansion;
f = Fraction of stroke complete at cut off;
c = Clearance per cent.

The clearance is not given, but may be assumed to be 5 per cent.; f was given as ¼ or 0.25.

The ratio of expansion would nominally be 1 divided by the fraction of the stroke complete at cut off or $\frac{1}{0.25}$ but corrected for clearance becomes

$$\frac{1 + 0.05}{0.25 + 0.05} = \frac{1.05}{0.3} = 3.5$$

From a table of hyperbolic logarithms $\log_e R$ is found to be 1.2528.

Now, substituting in the formula

$$P_m = (1 + 1.2528)(0.25 + 0.05) - 0.05$$
$$= (2.2528 \times 0.3) - 0.05 = 0.6258 \text{ lb.}$$

The total mean forward pressure will therefore be P_m multiplied by the initial pressure, which is given as 125 lb.

$$0.6258 \times 125 = 78.225 \text{ lb.}$$

From this must be subtracted the mean back pressure. As neither this nor the point of the beginning of compression is given, it may be assumed to be 2 lb. above the atmosphere, making the total back pressure

$$15 + 2 = 17 \text{ lb.}$$

Subtracting this from P_m gives

$$78.225 - 17 = 61.225 \text{ lb.}$$

as the mean effective pressure. This is the P, in the well known formula for horsepower

$$\text{Hp.} = \frac{\text{Plan}}{33,000}$$

where

l = Length of stroke in feet;
a = Area of piston in sq.in.;
n = Number of strokes.

l was given as 36 in. or 3 ft. a is equal to the area of a circle 20 in. in diameter or

$$a = 0.7854 \times 20^2 = 314.16 \text{ sq.in.}$$

n is equal to twice the revolutions per minute or

$$90 \times 2 = 180$$

Now, substituting in the last formula

$$\text{Hp.} = \frac{61.225 \times 3 \times 314.16 \times 180}{33,000} = 314.745$$

The horsepower at 110 r.p.m. may be obtained by dividing the above by 90 and multiplying by 110.

$$\frac{314.745 \times 110}{90} = 384.688 \text{ hp.}$$

ENGINEERS' STUDY COURSE

Logarithms—Part III

In the two preceding lessons on logarithms we learned how to find the logs of given numbers and the numbers corresponding to given logs. In this lesson we will proceed with some practical examples for the working of which it will be necessary for the student to procure a table of logarithms. As mentioned before, these tables may be found in most engineers' handbooks.

Rule: *To multiply numbers, add their logarithms. The sum will be the log of the product.*

Example: What is the circumference of a flywheel 24.5 ft. in diameter? To find the circumference we multiply the diameter by 3.1416.

The characteristic of 24.5 being 1 less than the number of integer places is 1, and that of 3.1416 is 0. The mantissa of each log is found from the table and the complete logs are as follows:

$$\begin{array}{rl} \log \text{ of } 24.5 & = 1.3891661 \\ \log \text{ of } 3.1416 & = 0.4971509 \\ \hline & 1.8863170 \\ & 0.8863158 = \log \text{ of } 76.969 \\ \hline & 12 \end{array}$$

Adding we find the log of the product to be 1.8863170. The nearest log to this in the table is 8863158, which corresponds with the number 76,969, and the characteristic being one we point off

$$1 + 1 = 2$$

places of whole numbers, making the number 76.969. Obviously there is no need of carrying this number out to a greater number of decimal places.

Rule: *To divide, subtract the log of the divisor from the log of the dividend. The remainder will be the log of the quotient.*

Example: How many gallons in a tank containing 80,619 cu.in.?

One gallon contains 231 cu.in. Hence we must divide 80,619 by 231.

$$\begin{array}{rl} \log \text{ of } 80{,}619 & = 4.9064374 \\ \log \text{ of } 231 & = 2.3636120 \\ \hline & 2.5428254 = \log \text{ of } 349 \end{array}$$

Here the characteristic of the log of the difference is 2. The mantissa is found in the table and corresponds to the number 34,900; and as the characteristic is 2 we point off three integer places in the number, and as the ciphers have no value we reject them.

Instead of subtracting we might have added the arithmetical complement of the log of 231, i.e., the difference between that log and zero

$$0 - 2.3636120 = -7.6363880 - 10$$

and then subtract 10 from the sum thus,

$$\begin{array}{rl} & \log \text{ of } 80{,}619 = 4.9064374 \\ \text{ar. com. of log. of } & 231 = -7.6363880 \\ \hline & 12.5428254 \\ & 12.5428254 \\ & 10.0000000 \\ \hline & 2.5428254 \end{array}$$

This is the same result we got by subtracting. This method is particularly useful when multiplications and divisions occur in the same example.

What horsepower would be developed by an engine 24 in. in diameter, 46-in. stroke running at 75 r.p.m., with 38.27 lb. m.e.p.?

$$\begin{array}{rll} & \text{P} & \log \text{ of } 38.27 = 1.5828585 \\ \text{L} & \left\{ \begin{array}{ll} & \log \text{ of } 46 = 1.6627578 \\ \text{ar. com.} & \log \text{ of } 12 = -2.9208188 \end{array} \right. & \\ \text{A} & \left\{ \begin{array}{ll} & \log \text{ of } 24 = 1.3802112 \\ & \log \text{ of } 24 = 1.3802112 \end{array} \right. & \\ & \text{N} & \log \text{ of } 0.7854 = -1.8950909 \\ & & \log \text{ of } 150 = 2.1760913 \\ & \text{ar. com. of log of } 33{,}000 = -5.4814861 \\ \hline & & 2.4795258 \\ & & 177 = 301.66 \text{ hp.} \end{array}$$

The arithmetical complement may be written directly from the table by putting down instead of the figures there given, the difference between them and zero, which will be for the first or right-hand figure the difference between the number as given and 10, and for all the rest the difference between the given figure and 9. If the characteristic is plus, i.e., if the quantity dealt with is an integer the characteristic will be minus, and one more than the characteristic of the log, as seen below

$$\begin{array}{rl} & 0.0000000 \\ \log \text{ of } 12 = & 1.0791812 \\ \hline & -2.9208188 \end{array} \qquad \begin{array}{rl} & 0.0000000 \\ \log \text{ of } 33{,}000 = & 4.5185139 \\ \hline & -5.4814861 \end{array}$$

When the characteristic of the log is minus, i.e., when a fraction is dealt with

$$\begin{array}{rl} & 0.0000000 \\ \log \text{ of } 0.7854 = & -1.8950909 \\ \hline & 0.1049091 \end{array}$$

the characteristic will be plus one less than the characteristic of the logarithm.

$$\begin{array}{rl} & 0.0000000 \\ \log \text{ of } 0.00075 = & -4.8750613 \\ \hline & 3.1249387 \end{array}$$

Rule: *To raise a number to any given power, multiply its log by the exponent of the power.*

If we wish to raise 25 to its third power we would have to perform the operation

$$25 \times 25 \times 25 = 15{,}625$$

This example could be done by multiplying the log of 25 by 3, thus,

$$\begin{array}{rl} \log 25 & 1.397940 \\ & 3 \\ \hline \log 25^3 & = 4.193820 = 15{,}625 \end{array}$$

Suppose we wanted to find 6^8, the eighth power of 6, we would have to do much figuring to get this by ordinary arithmetic. By the use of logarithms it is very easily obtained. We multiply the log of 6, which is 0.7781513 by 8, which gives 6.2252104, and the corresponding number is found to be 1,679.616.

Many problems are met with where it is necessary to raise a number to a fractional power. This operation is usually very difficult by ordinary arithmetic, but is easily performed by the use of logarithms. For example, you have often seen the expression $PV^{\frac{17}{16}} = \text{a constant}$. This expression means that the value of P is to be multiplied by the value of V raised to the seventeenth power and the sixteenth root extracted.

We raise the value of V to the seventeenth power by multiplying its logarithm by 17, then dividing the product by 16, we get the logarithm of the sixteenth root of the seventeenth power. Having obtained this log, all that is necessary is to find its corresponding number.

Usually it simplifies matters to reduce fractional exponents to decimal form. Thus the above $\frac{17}{16} = 1.0625$, which is the exponent.

Suppose we want to find the value of $746^{\frac{7}{8}}$. We must raise 746 to the seventh power and extract the eighth root.

By logarithms it is done thus:

$$\begin{array}{l}\text{The log of } 746 = 2.8727388 \\ \qquad\qquad\qquad\qquad\qquad\quad 7 \\ \hline 8)20.1091716 \\ \qquad 2.51364645\end{array}$$

The number corresponding to the log 2.51364645 is 326.222 ans.

To extract the root of a number we divide the log of the number by the index of the root, and find the number to which this log corresponds.

Example: Find the cube root of 3.1416.

$$\begin{array}{l}\text{log of } 3.1416 = 0.4971509 \\ 3)0.4971509 \\ \hline 0.1657169\end{array}$$

The number corresponding to log 0.1657169 = 1.46459.

Example: $\sqrt[6]{272}$ = log of $272 \div 6$.

$$\begin{array}{l}\text{log of } 272 = 2.4345689 \\ 6)2.4345689 \\ \hline 0.4057615\end{array}$$

$$0.4057615 = \text{log of } 2.545432$$

In this last example we carried the number out to six decimal places, but for all ordinary calculation three places is sufficient.

Instead of writing a minus sign before the characteristic when it is negative, it is common to express it as

$$9.\ mantissa - 10$$

However, when the cube root is to be found, this involves a fraction when dividing by 3; therefore it is better to use for minus 1 ($\bar{1}$)

$$29.\ mantissa - 30$$

which is equivalent to characteristic 9 minus 10.

Example: Find the cube root of 0.124.

$$\text{log of } 0.124 = \bar{1}.093421$$

Instead of expressing this as 9.093421 — 10, we write it

$$29.093421 - 30$$

Now dividing by 3

$$\begin{array}{l}3)29.093421 - 30 \\ \hline 9.697807 - 10\end{array}$$

Now we find the number corresponding to the mantissa

$$697807 = 49{,}866$$

As our characteristic is negative we know that this number is wholly decimal. Therefore,

$$0.49866 = \sqrt[3]{0.124}$$

The student can now appreciate the value of logarithms for raising numbers to high and fractional powers and for extracting cube root and all higher roots. Regarding the extracting of roots above cube root a good thing to remember is that logarithms are nearly always necessary.

In the Dec. 14 issue it was stated that when the index is an odd number, subtract 3 from it and divide the remainder by 2, extract the square root that number of times and then take the cube root. As an example it was stated.

"To get the seventh root

$$7 - 3 = 4;\ 4 \div 2 = 2$$

So we take the square root twice and then extract the cube root, and the sum of all these indices or exponents will be

$$2 + 2 + 3 = 7."$$

This was a mistake. The subtracting of 3 from the exponent gave the quotient of the original quantity divided by the cube of that quantity, not the cube root. The student should use logarithms in solving such problems.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

An "Engineering News" correspondent is dead set against the "reversed dam." He says "its stability depends upon its being perfectly glued to a solid rock foundation"; that he's "intensely serious about this matter." Sure! Must have been something wrong with the glue in all the reversed dams we've ever seen. What is this dam glue, anyhow?

Blink Boffum, the popular young electrician at the Bunktown lighting plant, takes his pen in hand to say that he has fully recovered from his "fall" off the H_2O shay. Blink denies the report that he was pushed off, says he just sort of slipped down. But he's clumb back, and swears he's agoin' to stay put.—"Bunktown Progressive."

The staff writers on the Jewish newspapers in New York City struck recently for a five-hour day, overtime, and a few other modest demands. How lucky we engineers are! We can work as long as we want to—and even longer. It's one wild bacchanalian revel with us. We ought to pity these poor scribblers who are thus rudely torn from their benches after five hours' light exercise and forced to idle about until tomorrow.

An Arizona workman was caught in a flywheel, whirled about, thrown into a pit 20 ft. away, and then got up uninjured and went back to work. Then he kicked because his jumper was torn! No gratitude in some people. He ought to be glad he wasn't docked for the time he lost while aimlessly flying around this way.

At the time of the economizer explosion at Saylesville, R. I., when the boiler plant was wrecked a team of horses attached to a wagon stood within 30 ft. of the building. Brick and other débris flew about the horses and half filled the wagon, and yet the horses stood their ground without moving. This must be an example of what people call horse-sense. Now, we suppose some brute will upset a really remarkable incident by informing us that the horses were deaf.

We are skeptical of the old saw which buzzes forth that "Music hath charms to soothe the savage breast." A German engineer, one Puritz, climbed into the Hamburg Opera House orchestra one night and slammed Musical Director Klemperer over the bean. It is just possible that the music lacked the necessary soothing syrupiness to control the tumult in Puritz' chest. The opera was "Die Gotterdammerung," not a peaceful expression, to say the least.

Another slander! Newspaper says that "Limburger is the only cheese that has stuck to the common people, all the others being too high-toned." Exception, your honor! We are prepared to admit counsel's statement that the defendant is guilty of a high tone (See Exhibit "A"), but we take objection to plaintiff counsel that it (the cheese) has "stuck" to the common people. Any sensitive man will be quickly moved to tears as its first zephyr is wafted to his nostrils—but, stuck! Not unless he eats it. Objection sustained.

London dispatches make a great howdydo over King George having a chill. Godfreys crickets! anybody can have a chill who wants it—and many have one wished on them. If a king can't have a chill during the reign, what's the use of—Don't mind'em, friend king, the papers are always pestering some one or other. Come on down to the plant after you knock off for the day; we'll fix you up.

Independent Air Pump for Condenser*

SYNOPSIS—Its advantages and development and a comparison between rotary and direct-acting pumps.

The most obvious advantage of an independent air pump is its ability to obtain a vacuum in the condenser before the main engines are started, thereby enabling the engines to be manipulated with greater ease and certainty at times when immediate response is of importance. On this account, the first adoption of such pumps was on board war vessels, and later for small river steamers, while the advent of the marine steam turbine made the provision of such pumps a practical necessity.

The earliest designs of independent air pumps were those in which the pump was driven by an independent crankshaft engine, and when the variable and peculiar nature of an air-pump load is considered, it will be obvious that a meager degree of success was possible, and that many failures resulted. Greater success was obtained when the air pump was coupled to the independent circulating engine, as these engines were under a considerable continuous load, and the variations of the air-pump load were not so vital in their effect, but even this arrangement was frequently unsuccessful, particularly where lack of care was shown in the details of design.

The direct-acting independent air pump was originally developed in the United States, while in its details it was perfected in Great Britain and in the form of the "Twin" air pump thoroughly satisfactory results were obtained. A further degree of simplification in design was the advent of the "Monotype" pump, in which a single air barrel of the three-valve type was driven by a single steam cylinder, and even now this constitutes a very successful type of pump for certain conditions. The suction-valveless pump, the features of which were originally enunciated in 1879, and which is now known as the Edwards air pump, offers distinct advantages as a type of air end for use as a lever-driven pump, but due to the principle of working, it is unsuitable for independent drive, and accordingly the old three-valve air pump has still maintained its position as the most efficient air end for independent working.

When, however, the principle under which air and water should be withdrawn from a condenser is considered, it is obvious that the "Twin" or "Monotype" pumps require to be very large on account of their handling the air and water together. Where of small dimensions, an undue degree of cooling of the feed water is necessary to enable them to obtain the desired vacuum, except under conditions of very slight air leakage. As already pointed out, it was early evident that the maximum efficiency would only be obtained by a combination of wet and dry pumps.

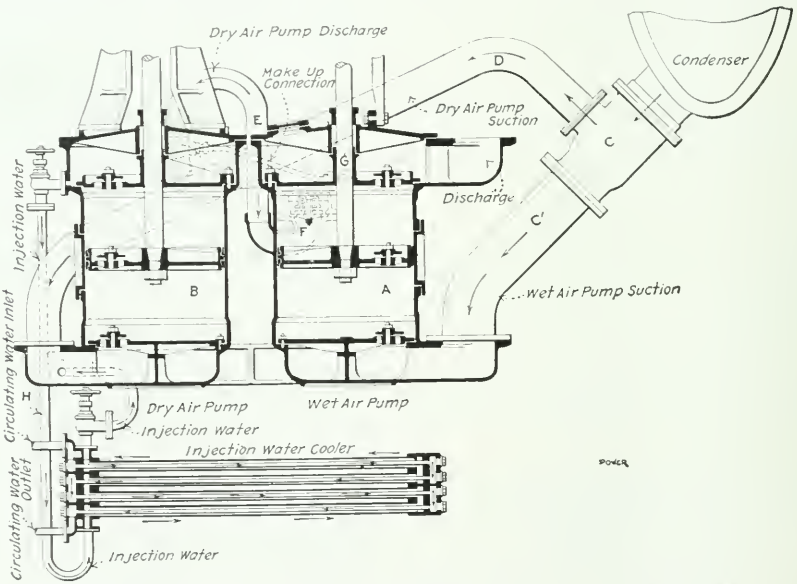


FIG. 1. SECTION OF WEIR "DUAL" AIR PUMP, COOLER AND CONNECTIONS

In the early stages of turbine propulsion many forms and combinations of wet- and dry-air pumps were fitted, but unfortunately these installations, in the majority of cases, were rendered apparently noneffective on account of faulty condenser design, and the present design of "Uniflux" condenser is a direct outcome of the apparent nonsuccess of the independent dry-air pump. Having succeeded in finding a satisfactory condenser design, the field was consequently clear for a fresh application of the wet- and dry-air pump principle. The main object was to secure a wet and dry pump, in one unit, in order to obtain an apparatus of minimum weight, of greater simplicity

*From paper read by William Weir before the Institution of Engineers and Shipbuilders in Scotland.

and steam economy, together with greater reliability than had been possible with the separate wet and dry pumps. These advantages have been secured in the "Dual" air pump in a simple and compact form.

Fig. 1 shows, in diagrammatic form, the arrangement of surface condenser, "Dual" air pump, and injection-water cooler. In all cases the wet pump *A* is situated below the steam cylinder, as this pump is the one which works under the maximum load. The dry pump *B* is driven by the beam and links in the usual way. One connection *C* is made to the condenser, but a branch pipe *D* is led to the dry pump, the connection being made in such a manner that the water will all pass by *C* to the wet pump. Apart from the separate suction arrangements to each pump, the "Dual" pump differs from the ordinary twin pump in that the dry pump discharges through the return pipe *E*, through a spring-loaded valve *F*, into the wet pump, at a point below its head valves. This spring-loaded valve is adjusted to maintain about 8 in. of mercury difference of pressure between the condenser, and what might be termed the hotwell of the dry pump.

The next point concerns the supply of water to the dry pump for water-sealing, clearance-filling, cooling and vapor condensation. When starting the pump, the filling valve *G* is opened for a short period, to enable the vacuum to draw in a supply from the hotwell of the wet pump. The valve is then closed and the water passes from the hotwell of the dry pump by the pipe *H* to an annular cooler through which a supply of sea water is circulated, and after being cooled the injection water passes into the suction of the dry pump, through the pump, and returns to the cooler in a continuous closed circuit; any excess caused by condensation passing over by the pipe *E* to the wet pump.

The advantages secured by such a combination are: A wet-air pump working approximately at the temperature due to the vacuum, in combination with a dry-air pump working at a much lower temperature, on account of which it is enabled to handle air leakage without any substantial cooling of the main body of feed water; a dry-air pump of high efficiency, due to it only requiring

COMPARATIVE CAPACITIES AND WEIGHTS OF AIR PUMPS

Vessel	Condensed steam per hr. per pump	Rate in lb. per Hp. per hour	Type of Air Pump	Designed Vacuum inches	Volume swept by bucket Volume feed water	Lb. weight of pump per Hp. of main engine
S.S. "Kronprinz Wilhelm"	255,000	17	"Twin"	26	12 4	2.09
S.S. "Franconia"	90,000	15	"Dual"	26	7 4	1 102
Battleship (1902)	67,500	16	"Twin"	26	15 4	2 16
Battleship (1912)	94,500	14	"Dual"	28 5	13 3	1 377
Turbine Atlantic Liner	196,000	14	"Dual"	28 5	13 2	1 232
Destroyer (1907)	124,000	16	"Monotype"	26	12 7	0 765
Destroyer (1912)	177,625	14 5	"Dual"	28	8 8	0 466
Small Turbo-Generator Set	6,000	..	"Monotype"	28	33	
Dredger Installation	15,000	..	"Monotype"	25	30	
Three-Throw Edwards type for Electric Power Stations	.		....	28 5	45 5	
Weir "Dual" Air Pump for Electric Power Station	80,000	..		28 5	20 5	
S.S. "Campania"	40,000	..	Engine-driven ordinary	25	60	
Cargo Steamer	255,000	..	Engine-driven ordinary	25	45	
S.S. "Rangatira"	40,000	..	Engine-driven "Dual"	25	26 5	

to discharge against 4-lb. pressure instead of 15-lb., as in the case of an ordinary air pump.

The factors involved in the estimation of the correct size of air pump to employ, comprise in the first place considerations of the normal air leakage which the pump must deal with. This question is associated with the actual size of the installation. In a small installation the air leakage is always relatively higher than in a large one. It is further complicated by the nature of the installation.

The table shows the wide variation of practice, giving the capacity in terms of air-pump bucket volume swept to feed-water volume, also the weight of a number of air-pump installations, from which it may be noticed that the present-day degrees of high vacua are obtained with less weight and capacity than the older arrangements of, say, ten years ago. This arises in a certain degree from improved air-pump design and also to the greater care taken to avoid air leakage.

It is of interest to note the large difference in capacity between the ordinary engine-driven air pump and the independent air pump, while the capacity usually provided for electric-power-station practice appears excessive. The average steam consumption of independent "Dual" air pumps for vacuums of 26 to 28.5 in., expressed as a percentage of the feed water they handle, varies from 0.65 to 1.

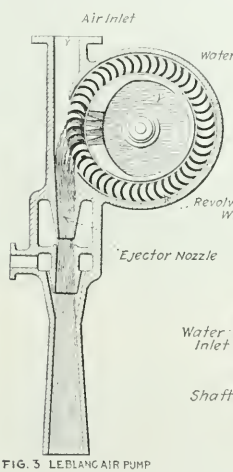


FIG. 3 LEBLANC AIR PUMP

FIG. 2 SCHIELE AIR PUMP

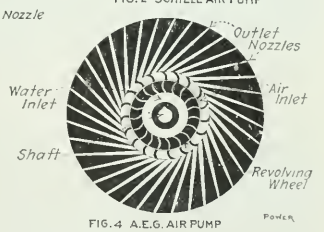


FIG. 4 A.E.G. AIR PUMP

During the last few years much interest has been taken in the development of rotary dry-air pumps, especially for electrical-station practice on the Continent; the two most notable examples are associated with M. Leblanc, of Paris, working in conjunction with the Westinghouse Co., and the rotary air pump constructed by the A. E. G. Co., of Berlin. While the utmost credit should be accorded to M. Leblanc for having developed the modern type of rotary air pump, it is of interest to note that in 1862, Christian Schiele, of Oldham, invented and built a rotary air pump regarding which he claimed:

"The system or mode of expelling air from condensers by combining or entraining it with injection water on its passage through a fan or centrifugal pump."

Fig. 2 shows the original Schiele pump, in which it will be seen that the water enters through a series of fixed openings, passes into a turbine wheel along with the air and vapor, in which it is given the necessary velocity to discharge it through guided passages to the atmosphere.

Fig. 3 shows a section of a modern Leblanc air pump in which a single ejector and nozzle is used for discharg-

ing the air and injection water, the combination or admixture of the two taking place outside the turbine wheel.

The A. E. G. design of rotary air pump shown diagrammatically in Fig. 4 is practically a Leblanc pump having a series of specially-shaped nozzles arranged circumferentially, the point where the air meets the entraining water being, as in the Leblanc pump, between the rotating wheel and the nozzles.

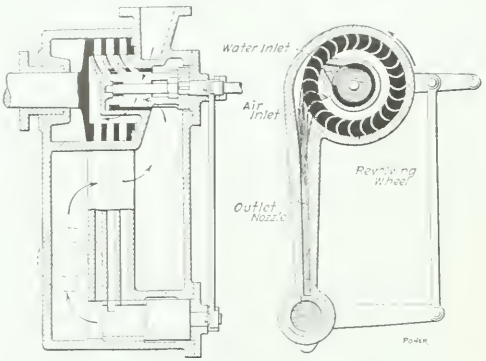


Fig. 5. Weir Rotary Air Pump

For marine use the adoption of rotary dry-air pumps has been comparatively slow, due in a large measure to the very onerous and varied requirements to which a marine pump has to conform, and further, to the extremely efficient nature of the existing direct-acting machinery. The necessity for driving such rotary machines by small steam turbines, in themselves still more or less in the development stage, necessarily implies high steam consumption, while even the best rotary air pumps require the absorption of a considerable power per unit of air removed. Further, the existing types do not appear to possess any degree of flexibility, in the sense that being velocity machines they must always run at the designed speed and accordingly use the same amount of steam, thus causing their performances at low powers of the vessel to be fairly inefficient.

Fig. 5 shows a recent development of the ordinary Schiele pump, which has been designed with the object of imparting to it a certain degree of flexibility. As will be seen, it differs from the Leblanc and A. E. G. types in that the air is brought into contact with the injection water in the wheel itself—somewhat similar to the Schiele pump—both passing through the wheel before being ejected through a simple nozzle; while in addition the wheel is constituted of four units, each being provided with a nozzle, and provision being made for closing any unit as desired, it enables the pump to run with whatever number of units are required to maintain the desired vacuum.

While it is probable that the entrainment type of rotary air pump may be further developed, its ability to handle heavy air leakage only by the use of considerable power rather handicaps it for marine work at present. Fig. 6 gives a representation of the characteristic performance of a modern marine rotary air pump at varying air leakage, while on the same diagram there is shown the performance of a direct-acting pump. As regards the proportions of the two pumps, their weights are identical, provided no allowance is made for the cooler and tank necessary for the rotary air pump. The relative steam consumptions of the two pumps, when doing the duty shown on the diagram, is as follows:

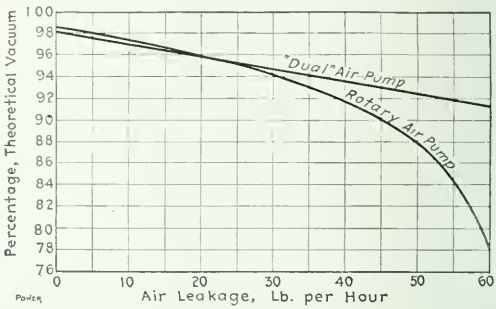


Fig. 6. "Dual" and Rotary Air-pump Performances

Direct-acting pump..... 800 lb. per hr.
Turbine-driven rotary pump... 3500 lb. per hr.

As may be seen from the diagram, the rotary pump maintains a very slightly higher vacuum than the direct-acting pump at small leakages, but rapidly falls off at large leakages.

[That portion of the paper devoted to feed-water heating and feed pumps will be published in a later issue.—Editor.]

Economizer Explosion at Saylesville

By the explosion of an economizer at the Glenlyon Dye Works, a branch of the Sayles Bleachery, Saylesville, R. I., at 4 p.m., Tuesday, Jan. 14, two men were killed and seven others were more or less seriously injured, one probably fatally. One section of the boiler house and the engine room were demolished.

A brick wall divided the power plant into two boiler rooms. In one, six 325-hp. water-tube boilers were installed, each connecting with a main steam header running the length of the boiler room. In the second boiler room there were four 72-in. return-tubular boilers. A second brick wall, at right angles to the first, separated this boiler room from an engine room in which there was a Corliss engine, directly connected to a generator. The 72-in. boilers were each connected by a 6-in. branch pipe to a 12-in. header. A smoke flue extended to the brick chimney, entering at the opening shown in Fig. 1.

Two economizers, side by side on an I-beam platform, supported by iron columns, were next to the partition wall. Beneath the economizers were the heater and boiler-room auxiliaries. The smoke flues of the water-tube boilers were connected to the economizers after passing through the brick wall between the two boiler rooms. As the economizers were in the boiler room containing the return-tubular boilers, it was here that the greatest damage was done.

At the time of the explosion only one of the two economizers was in service, the outside one being cut out for some slight repairs. When the working economizer exploded it demolished the second.

So severe was the explosion that the entire end of the power house, which was about 125 ft. square, and 30 ft. high was demolished, the roof collapsing in a tangled mass over the small boilers and débris. Fragments of the economizers were thrown about the yard. Part of the chemical laboratory at the rear of the boiler room was also wrecked.

As both economizers were blown to pieces, the one in service must have contained a large amount of water at a high temperature. Although the economizers were nearest the water-tube boilers, the dividing wall protected the latter to such a degree they were uninjured, and can be put into service at any time.

As the force of the explosion was directed toward the return-tubular boilers, that part of the power plant suffered most. The boiler fronts were demolished, and the steam-pipe connections were broken, as shown in Fig. 2. Happily the sudden release of steam from these boilers did not cause a second explosion.

Fig. 1 gives an idea of the damage done. In the foreground are parts of the economizers, smoke flue and general débris. The partition wall between the two boiler rooms is shown back of the 150-ft. chimney; a part of it was blown out. The chimney was only slightly damaged.

FIG. 1. GENERAL VIEW OF THE WRECKED BOILER HOUSE, SHOWING DAMAGE DONE BY THE EXPLOSION OF AN ECONOMIZER

FIG. 2. FIRING FLOOR IN FRONT OF RETURN-TUBULAR BOILERS

FIG. 3. PARTS OF THE ECONOMIZERS

The water-tube boilers are shown at the right of the chimney. The economizers stood on the platform just back of the chimney, Figs. 1, 2 and 4. Some of the larger sections of the economizer are shown in Figs. 2 and 3. No particular section appears to have been weaker than another; the headers were badly broken, the tubes broke off in the header in some instances, just outside in others, and at varying lengths, as shown.

Boiler-feed water was pumped from an open heater,

Fig. 4, through the economizers: therefore the latter would be under boiler pressure. The cause of the accident is unknown. A number of experts have examined the ruins, but can give no authentic information. A representative of the economizer manufacturer holds to the theory that gases leaked into the idle economizer, and exploded with sufficient force to rupture the working unit, the explosion of which did the damage. Both were connected to a single smoke flue connected with the chimney.

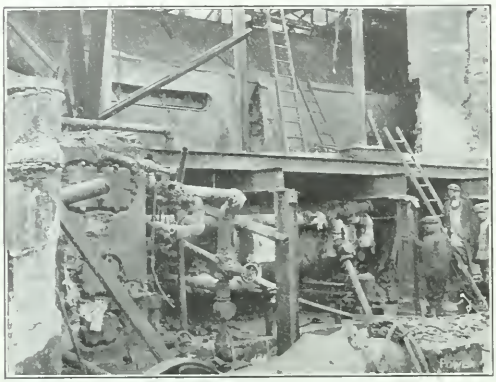


FIG. 4. AUXILIARY APPARATUS UNDER THE ECONOMIZER PLATFORM

So suddenly did the explosion occur that the two men who were killer were buried under fallen bricks and general débris where they stood. The body of fireman Hassan Momoth was not recovered from the ruins until 16 hr. after the accident, although search for the body was continued throughout the night. His body was finally located in front of the return-tubular boilers. August Blank, a piper, the other man killed, was found pinned to the concrete floor of the boiler room by a piece of roof girder. Death in both cases was doubtless instantaneous. Three men were released from the wreckage in about 30 min., a fourth, an ash man, was found in about an hour, unconscious and in a critical condition. Of the ten men in the power plant at the time of the accident, but one escaped uninjured. He was standing in the center of the boiler room near the heater when the explosion occurred.

Both Green economizers were 12 years old. The boilers and economizers were operated as they had been all day. They were insured by the Hartford Steam Boiler Inspection & Insurance Co. It is not known just what the loss will be, but it will amount to several thousands of dollars. It is doubtful if the return-tubular boiler will again be put into operation.

Frank B. Monaghan's Memory Honored

In the presence of nearly 200 friends and associates, including many prominent labor officials, a monument was dedicated on Jan. 12, at Calvary Cemetery, Boston, Mass., to the memory of Frank B. Monaghan, organizer and a former president of the International Union of Steam Engineers. Inclement weather necessitated an early adjournment to the Revere House, Boston, where the exercises were continued under shelter. James Duncan, first vice-president of the American Federation of Labor and a close friend of Mr. Monaghan, delivered the dedication oration, and in the course of his address said:

Monuments throughout the world have generally been erected in the memory of military or naval heroes, and have been connected with the spilling of blood. This shaft has been raised for a nobler purpose, in the memory of one who devoted his whole being to the conserving of life and the betterment of the condition of humanity.

The monument is 9 ft. in height, sarcophagus in form, with a representation of a steam gage on its face, the indicator hand pointing to 50, the age of the deceased leader of engineers.

International Refrigeration Exposition

It has been previously announced that during the third International Congress of Refrigeration at Chicago in September, 1913, an exposition of refrigeration will be held. The arrangements are perfected and the association thoroughly organized for holding this exposition in the amphitheater at Forty-second and Halsted Sts., the largest building of its kind in Chicago. It is equipped with trackage connection with all of the railways entering the city. Everything pertaining to refrigeration will be exhibited, cars, machinery of all sorts in active operation, fruits, game, poultry, meats, vegetables, eggs, butter and cheese. With the 500 or 600 delegates from Europe and South American countries and kindred conventions of American ice makers, meat packers, poultry, game, butter and egg people and others, nothing equaling the importance of this exposition has been undertaken since the World's Fair, says the committee:

The officers and directors are: President pro tem., William L. Wagner; vice-president, Frank L. Nickerson; general manager, William E. Skinner, with office at 819 Exchange Ave. Directors, including the officers: Theodore O. Vilter, John S. Field, F. S. Pilsbry, Arthur Meeker, H. C. Gardner, C. M. Secrist, George E. Haskell, A. D. White and H. W. Hart.

SOCIETY NOTES

The National District Heating Association will hold its fifth annual convention in Indianapolis, Ind., on May 27-29. The association promises a program of unusual benefit and interest, and urges a large attendance.

A. R. Maujer, Western editor of "Power," and a member of Illinois No. 1, lectured before the Chicago Association of Stationary Engineers on Wednesday evening, Jan. 15, on "Proximate Coal Analysis and Its Value in Power Plant Economy." The lecture was demonstrated with actual apparatus and the method employed clearly illustrated. This lecture will be entered in the national prize contest for the indicator outfit offered by the National Educational Committee.

PERSONALS

Manager E. Holcomb, of the Consumers Power Co., St. Paul, Minn., has been elected president of the Minnesota Electrical Association for 1913.

Staege & Bennett, consulting civil, steam and electrical engineers, Watertown, N. Y., have moved their offices from the Smith Building to the Charlebois Building, in that city.

Charles W. Naylor lectured before the Armour Institute Branch, N. A. S. E., on Jan. 15, taking as his subject the Marshall Field power plant, of which he is the chief engineer.

Herbert E. Stone is the New England representative of the Pittsburgh Piping & Equipment Co., piping contractors, engineers and machinists, with offices in the Equitable Building, Boston, Mass.

Errata: In the description of the Worthington Turbo Blowers and Compressors in the Jan. 7 issue, page 12, a very obvious mistake occurred. A turbo compressor referred to was described as operating against a pressure of 1000 lb.; it should have been 100 lb.

POWER

Vol. 37 NEW YORK, FEBRUARY 4, 1913 No. 5

Plant of Packard Motor Car Co.

By A. R. Maujer

SYNOPSIS—Outline of the rapid growth of a direct-current plant which in 1903 was of only 350 hp. capacity and today has 8000 hp. capacity in electric-generating equipment alone. The 3000-hp. main units, at the time of their installation, were the largest ever installed for 240-volt service.

Designing any power plant usually involves certain problems peculiar to it alone in addition to the general problems common to all. In the Packard Motor Company's plant in Detroit the special problems were caused by the rate at which the demands upon it have increased. The automobile industry is an unusual one because of its unprecedentedly rapid growth. The Packard works represent no small part of that growth and every second year thus far has seen an increase in the capacity of the present power plant equivalent to 200 per cent. of that of the original installation.

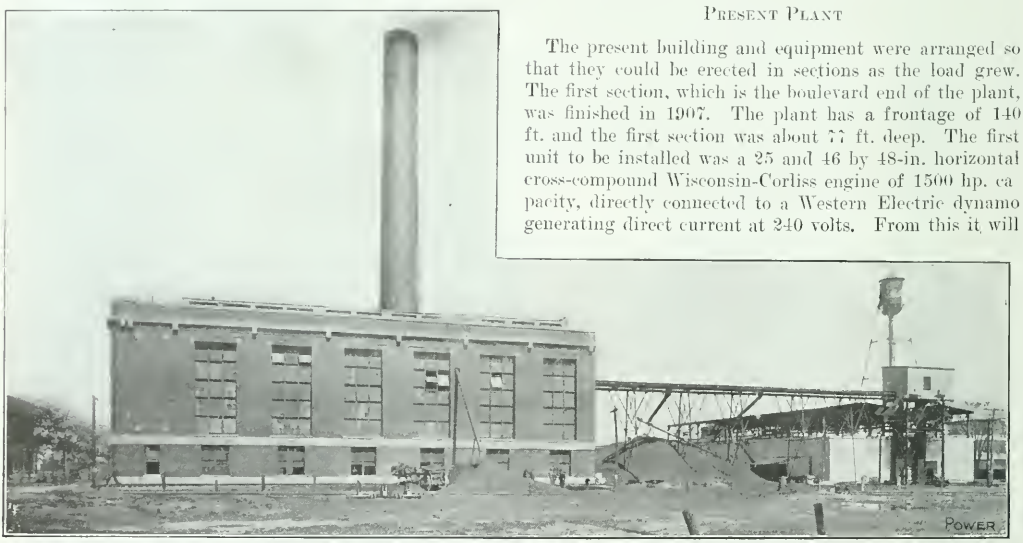


Fig. 1. New Plant of the Packard Motor Car Co., at Detroit, Mich.

The Packard works are on the outskirts of the city, on East Grand Boulevard, a wide, well made and much used thoroughfare. The executive offices front on one side of the boulevard and the power plant stands just opposite. Because of the conspicuous location of the plant special attention was paid to the external finish of the building; the walls are faced with selected hard-burned red brick and trimmed with granite. A side view of the plant is given in Fig. 1.

Original Plant

The original plant, built and put into operation in 1903, was modest enough, having an engine room but 50 ft. square, which contained one 350-hp. tandem-compound Ball high-speed engine driving a direct-current dynamo. Two McNaul 200-hp. water-tube boilers equipped with Detroit automatic stokers supplied the steam. The plant also contained one Blake & Knowles underwriters pump of 1000 gal. per minute capacity and one 6x4x6-in. Laidlaw-Dunn-Gordon duplex boiler-feed pump.

In the following year another 200-hp. McNaul boiler, another 250-hp. Ball engine and a Franklin air compressor of 350 cu.ft. per min. capacity were added to the equipment.

A year later, in 1905, a 500-hp. Ball engine was installed together with another boiler, another feed pump and an air compressor of 100 cu.ft. per min. capacity. By this time the full equipment as laid out in the original plans was in operation and there was no satisfactory way in which to increase the capacity of the plant or make an extension. Consequently, to provide for the rapidly occurring increases in the power requirements, an entirely new plant was laid out.

Present Plant

The present building and equipment were arranged so that they could be erected in sections as the load grew. The first section, which is the boulevard end of the plant, was finished in 1907. The plant has a frontage of 140 ft. and the first section was about 77 ft. deep. The first unit to be installed was a 25 and 46 by 48-in. horizontal cross-compound Wisconsin-Corliss engine of 1500 hp. capacity, directly connected to a Western Electric dynamo generating direct current at 240 volts. From this it will be seen that the size of the unit had been increased considerably since the first engine in the original plant was installed only four years before. It will be seen further that the size was to be increased still more, for when the second section of the plant was erected in 1908-9, adding 44 ft. to the depth of the building, a 38 and 70 by 54-in. C. & G. Cooper horizontal cross-compound Corliss engine of 3000 hp. capacity, driving another Western Electric 240-volt direct-current dynamo was installed, shown in Fig. 2. At the time this was the largest direct-current unit of that voltage ever installed in the United States.

Direct current was adhered to because it is easier to operate the generators in parallel and variable-speed motor operation was considered more satisfactory with

direct current and direct-current motors are better for machine-tool work. Then, too, the old equipment throughout the plant was arranged for direct current and to

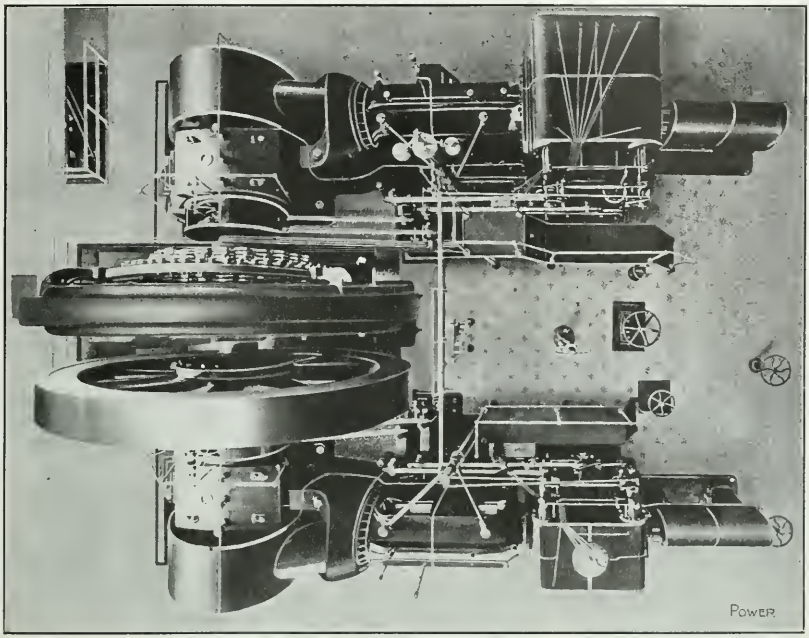


FIG. 2. BIRDSEYE VIEW OF THE COOPER ENGINE

change at this time would have meant complication in system and equipment.

VALVE-GEAR OF 3000-HP. ENGINE

A feature of the Cooper engine is the valve-gear shown in Fig. 3 and known as the Cooper improved gravity latch gear. The points to commend this gear are its noiseless operation, simplicity and accessibility. The latching or hooking-up operation is performed by a pick-up plunger, through the action of gravity. The pick-up plunger guide block has an auxiliary spring attachment which can be brought into use instantly while the engine is in operation to assist the gravity-latching action of the pick-up plunger, if for any reason its gravity-latching action should become sluggish.

The releasing action is transmitted from the governor cam, through the roller arm and lifting bar, to the pick-up plunger. The end of the roller arm which engages the governor cam, is always in rolling contact on the governor-cam ring. The opposite end of the roller arm, where it is joined to the lifting bar, has an adjustment for changing the lap of the steel blocks, if any of the block edges become unduly worn or accidentally broken.

The engaging faces of the steel block on the pick-up plunger and the steel block on the steam crank are parallel, in a radial line extending perpendicularly from the center line of the valve stem. The pick-up plunger maintains this same radial line in all its working positions, due to its fixed path of travel in the pick-up plunger guide block. Therefore, after hooking up, the engaging faces of the steel blocks continue to remain parallel to each other up to the time release takes place. This parallel sliding motion of the block faces against each other, during their working periods, eliminates a common source of annoyance, viz.: the rounding off of the block edges. Owing to the flexibility of the pick-up plunger, its block automatically adjusts itself squarely and evenly against the block on the steam crank, so that the wear on the block faces is uniform.

The governor-cam rings are on the inner side of the bell cranks. This construction serves as an extra precau-

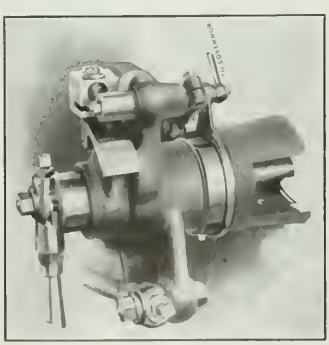


FIG. 3. DETAIL OF THE COOPER ENGINE VALVE-GEAR

tion to protect these important parts from accidental injury.

The safety and knock-off cams are combined in one

large cam. The governor-cam ring is formed to receive this combined cam in a recessed joint and in addition, a locknut is used to lock the cam securely in place. The object of combining these two cams in one larger cam, is to provide for absolute equalization of the cutoff in each end of the cylinder. This is brought about in the final setting of the valves, when it is only necessary to shift the combined cam, until equal points of cutoff are obtained. After this final adjustment has been made, equal points of cutoff will be maintained under all conditions of operation, from no load to full load. This adjustment feature effects a marked improvement in regulation and economy, when the engine is operating under variable load conditions.

The vacuum pots are of the piston type, sealed with oil grooves. If for any reason they should fail to act, the steam crank is automatically closed by the mechanical engagement of the bell crank against it.

Second 3000-hp. Unit

In 1910 the building was extended 44 ft. farther and a second 3000-hp. Cooper engine, a duplicate of the first, was installed to drive a General Electric direct-current dynamo.

Fig. 4 is from a recent photograph of the engine room, giving a view from the boulevard entrance. The 1500-hp. Wisconsin-Corliss engine stands at the extreme left and out of the field of vision. Next to it is the 3000-cu.ft. compressor, one air cylinder of which can be discerned at the left of the illustration. To the right are the two 3000-hp. Cooper engines. The wall, seen at the end, is a temporary one of wood, waterproofed on the outside. It has done duty for each successive section of the plant thus far, but when the fourth and final section is constructed it will be discarded for a permanent wall in keeping with the rest of the building. And it might be stated in passing that the rest of the building is particularly

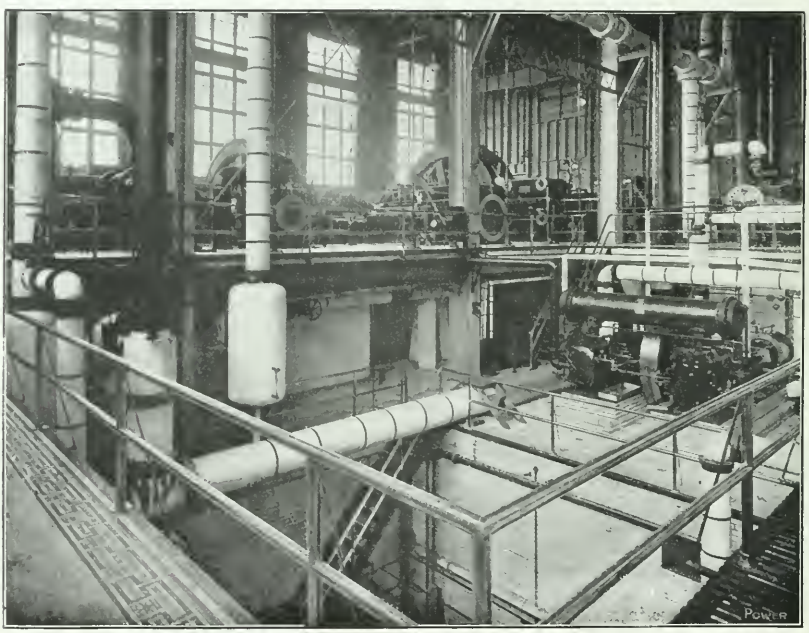


Fig. 4. View in the Engine Room of the Packard Plant

In 1909 an Ingersoll-Rand two-stage air compressor tandem connected to a Hooven-Owens-Rentschler horizontal cross-compound Corliss engine 20x32x42 in. in size, was also installed. This unit will compress 3000 cu.ft. of air per min. to 80 lb. pressure when operating at 85 r.p.m. The air cylinders are 19¼ and 32¼ in. in diameter, respectively.

In this same year the original plant, which had been kept in service until the new plant was far enough completed to take over the entire load, was dismantled. Two of the boilers from this plant and the two 250-hp. Ball engines, together with the necessary piping, the stokers, feed-pump and feed-water heater, were shipped to New York City and installed in the Packard service plant at Astoria, Long Island.

well finished and well kept. As the chief engineer, Fred Willins, expressed it: "We are proud of the plant, take good care of it, and respect it in every way as the heart of a big institution should be respected." The floor is finished in white tile set off with an artistic design and border of colored tile and a high wainscot around the walls is finished in white-enamel brick, as also are the pedestals of the various machines. Large windows in the front and side walls admit plenty of light and insure good ventilation.

A steel and glass partition divides the boiler and engine rooms so that, although no light is cut off from either during any part of the day, no dust or dirt stirred up in the former can invade the latter. Originally numerous inclosed arc lamps, hung from ornamental brackets from

the building columns or supported on special poles, provided the general illumination at night, while clusters of incandescent lamps furnished light where concentration was required. Recently, however, the arc lamps

FIG. 5. THE CENTRAL GAGE BOARD

have been supplanted by Cooper-Hewitt mercury-vapor lamps.

PUMPS

Referring to Fig. 4, the pit in the foreground contains the three boiler-feed pumps, the pumps for the heating returns and for the hot-water service throughout the building. The feed pumps are a Worthington outside center-packed horizontal duplex, 17x10x15 in. in size, and two Fairbanks-Morse 18x12x18-in. pumps of the same type. The feed-water main, 8 in. in diameter, is in duplicate; one main feeds into the upper drums of the boilers and one into the lower.

The hot-water supply for the various buildings is handled by either of two Blake-Knowles duplex 7½x5x6-in. pumps. The suction connects with the feed-water heater, and the discharge with the 4-in. supply main which serves all of the various buildings. A 1½-in. return pipe also connects with the heater so that the water may be circulated and a constant supply of uniformly hot water is therefore instantly available at all points.

The returns from the heating system flow back by gravity to a return tank in the pump pit from which they are lifted to the heater 30 ft. above by either a Marsh 12x18x12-in. outside center-packed duplex pump or a Weinman Machine Co. pump of the same time and size. The feed-water heater is on the engine-room side of the partition close to the pump pit. It is a Cochrane; when it was installed at the time the present plant was erected its capacity was 3000 hp.; this was increased later to 5000 by raising the top section and inserting an additional section.

The air compressor on the basement floor, as shown in Fig. 4, is the one of 1000 cu.ft. capacity taken from the old power plant when the latter was dismantled, and is installed in the new plant for emergency use. The engine, which may be seen just above it on the main floor, is the 500-hp. Ball engine, also taken from the old plant and employed in the new one for carrying the light and power load during the noon hour and at other times when the requirements are especially small.

GAGE BOARD AND SWITCHBOARD ARRANGEMENTS

Conveniently near the chief engineer's office is the central gage board, shown in Fig. 5, the equipment of which is unusually complete. The following pressures are shown: main steam header, fire-pump steam main, various engine receivers, compressed air, heating system, fire-pump discharge, intercooler and receiver of air compressor, city water and hot-water supply pressure. In addition, the board carries a recording voltmeter and a recording wattmeter.

Perhaps the feature that strikes a visitor to this plant the most forcibly is the absence of a general switchboard. Just back of each generator is a single panel on which are mounted the main switch, the circuit-breakers, the rheostat handles, and the ammeter and voltmeter for that particular unit. As for the feeder switches, instruments, etc., there are none, nor are any strictly necessary.

BOILER ROOM

In the boiler room, Fig. 6, are 11 Wickes vertical water-tube boilers, each of 400 hp. rated capacity, equipped with

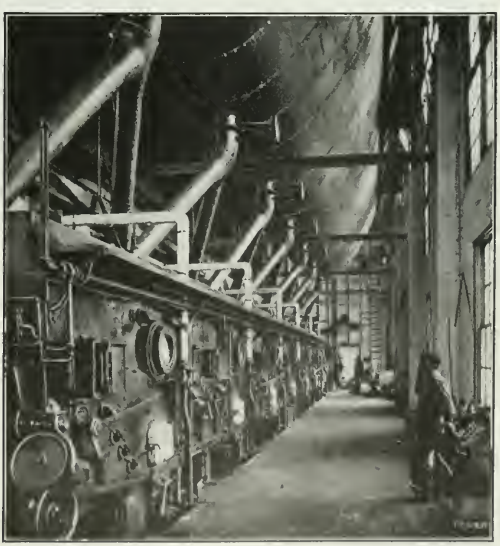


FIG. 6. VIEW IN THE BOILER ROOM

standard Murphy automatic smokeless furnaces. The steam pressure is carried at 150 lb. gage. An underground brick-lined flue connects the boilers with a radial-brick chimney 175 ft. high and 12 ft. in inside diameter. Coal

is fed to the furnaces by gravity from an overhead suspended type of sheet-iron bunker. The ashes drop through a hopper in the bottom of the ashpit into wheelbarrows in which they are carried to a bucket-elevator conveyor which lifts them to such a height that they may be discharged through a chute into cars on the railroad siding which lies alongside the boiler house.

A Sarco and a Precision Instrument Co. automatic flue-gas machine are so arranged that samples of the gas may be drawn from the chimney, the flue or from any boiler.

Coal Storage and Handling

The coal is stored in a concrete bin, as shown in Fig. 1. This bin is 140 ft. long by 74 ft. wide and is 30 ft. high from the ground line. Its capacity when filled by the coal-handling apparatus alone is 4000 tons and when trimmed by hand, 5000 tons. The coal is delivered in hopper-bottom cars on the siding alongside of the bin. From these it is dumped into a receiving hopper between the rails and fed to a conveyor which carries it to the crushers which are in the same pit as the receiving hopper. A bucket elevator raises the crushed coal to the overhead conveyor level. If the coal is required for immediate use it is fed to the conveyor, which may be seen extending into the boiler house in Fig. 1. This is a screw conveyor; a long spiral blade fitted into a trough forces the coal along until the outlets at various points in the overhead boiler-room bunker are reached. This bunker is 154 ft. long and has a capacity of seven tons per lineal foot. If the coal is to be stored, it is fed to two overhead bin conveyors, also of the screw type, and distributed evenly in the storage bin. A brick arch tunnel along the center of the bottom of the bin contains a conveyor which delivers the coal to the bucket elevator. This in turn delivers it to the boiler-house conveyor. Fig. 7, which is a view of the bin before it was completed, shows the return-conveyor tunnel with the openings in its side for receiving the coal.

Piping

A main header, 16 in. in diameter, runs the length of the first and second sections of the engine room, supported on brackets on the building columns about 26 ft. above the floor level. The 8-in. main leads from the boilers come through the partition about 14 ft. higher up and drop down to the header with long-radius bends. The leads to the main engines drop straight down to a steam separator just below the engine-room floor level and then extend across under the floor to the engine.

The main header for the third and fourth sections, also 16 in. in diameter, lies along the basement floor. The leads from the boilers are brought over in a semicircle 16 ft. 6 in. in diameter and make a vertical drop of 39 ft. to the header. The lead to each engine extends under the engine-room floor to a steam separator near the engine from which connection is made direct to the throttle. The two sections of the main header are connected with a 12-in. line controlled by a gate valve so that they may be isolated at will. Extra-heavy pipe with Van Stone joints is employed throughout.

An auxiliary header 10 in. in diameter and fed by separate 4½-in. leads from the boilers runs the entire length of the plant on the engine-room side of the partition supported on brackets 27 ft. above the engine-room floor line. In addition to supplying all the auxiliaries, this header furnishes all the high-pressure steam required throughout the works.

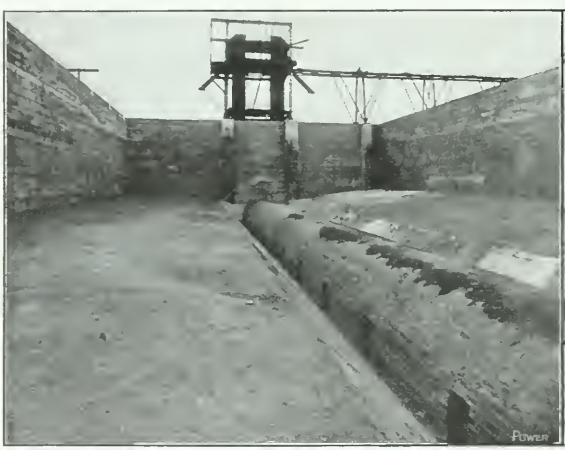


Fig. 7. The Concrete Coal Bin before Completion

Fig. 8. View on One of the Pipe and Wiring Tunnels

A second auxiliary header, 8 in. in diameter, connects with the two fire pumps and the fire whistle only. These pumps are a Blake-Knowles underwriters of 1000 gal. per min. capacity and a Fairbanks-Morse underwriters of 1500 gal. capacity. They are in the basement on the east side of the plant. A cross-connection between this fire-pump header and the 10-in. header allows connecting the two together if necessary.

The exhaust from the main units is collected in one main exhaust header, which varies in size from 18 to 26 in. From this two 16-in. leads are taken off for the heating system and run through the two main tunnels. A 10-in. connection supplies the feed-water heater. The exhaust from the auxiliaries is received by an 8-in. header which connects directly with the heater.

A 6-in. connection between the 10-in. auxiliary steam

header and the exhaust-steam heating main supplies live steam through a pressure-reducing valve whenever there is a deficiency of exhaust steam.

Tunnels

Tunnels are employed for distributing electricity, compressed air, hot and cold water, high-pressure steam and exhaust steam to the 27 buildings throughout the works, the combined floor space of which amounts to over 37 acres. One main tunnel, Fig. 8, runs directly north 1500 ft. It is built of brick and is 8 ft. wide by 8 ft. high.

When passing under the public street the tunnel is 12 ft. below grade, as required by law; on Packard property it rises to 1 ft. below. Another main tunnel of the same size and construction runs south 1100 ft. Smaller branch tunnels extend out from the main ones to serve those buildings which are not in direct line. Branch lines from the various air, steam and water mains extend into each building and a main electric feeder or a tap extends to a distributing panel in the basement.

Auxiliary Boiler Plants

In the drop-forge department, which is remote from the power plant, there are two 400-hp. Wickes vertical boilers equipped with Murphy furnaces and a Cochrane heater. These supply steam at 140 lb. pressure for the steam hammers; the exhaust is used for heating the forge and foundry buildings.

In a separate house is a 200-hp. McNaul boiler which generates steam at 250 lb. pressure for heating some enameling ovens. This boiler is fired by hand with wood, rags, waste and other combustible refuse from the works.

F. F. Van Tuyl, Detroit, Mich., is the consulting engineer for the Packard company, under whose supervision the plant was designed and erected. We are indebted to him for assistance in preparing the foregoing description.

Oil Fuel for Destroyers and Battleships*

SYNOPSIS—Advantages and disadvantages of oil as fuel. Its evaporative and thermal value as compared with coal.

In deciding to adopt oil fuel for use on battleships and destroyers, the Navy Department took into account the following advantages which would be gained by its adoption:

1. Less fuel required for any given radius of action, consequently less percentage of displacement and less bunker capacity required for the fuel.
2. Increased boiler efficiencies.
3. Decreased fireroom force.
4. Less deterioration of boilers due to maintenance of more even temperatures.
5. Ability to maintain high powers for indefinite periods.
6. Less deterioration of ship's structure due to there being no water or ashes in the bilges.
7. Greater cleanliness.
8. Greater ease in replenishing fuel supply, both in port and at sea.
9. Less floor space required for the development of a given power.
10. Greater ease in control of steam supply.

In opposition to these undoubted advantages the following disadvantages exist:

1. Fuel oil less widely distributed over the earth than coal.
2. Greater unit cost than coal.
3. Greater danger of fire than with coal.

The reply to the first disadvantage is that in time of war a fleet operating far from a base would depend upon fuel ships for replenishing her bunkers, and that oil can be carried in bulk as well as coal, and bases where stores of oil can be kept on hand are as easily established as are bases for coal, and such oil bases would have, in case of danger of capture by an enemy, the additional advantage of being much more readily destroyed, together with their stores of fuel, than are coal bases.

The second disadvantage, that of excess cost over coal, is more than compensated for by the quoted advantages.

The third disadvantage, that of danger from fire, is very thoroughly guarded against by storing the oil in compartments remote from the boiler rooms, and situated well below the water-line of the vessel. In addition to these primary precautions, additional safeguards are provided which render the danger from fire fully as remote as the danger from magazine explosions.

Upon deciding upon the adoption of oil as a fuel for the naval service, the Bureau of Steam Engineering examined carefully all the systems for burning oil that now exist and finally decided upon that of mechanical atomization of the oil as the one most suitable for naval use. In this system, the oil is pumped through heaters to the burners, within which it is given a whirling motion. The small central core of oil, discharging through the tip orifice with this whirling motion, the oil flies off and forms a cone of fine mist. This oil mist mixes thoroughly in the furnace with air which passes into the furnace through a cone register surrounding the burner, the register having adjustable openings and guide vanes so that the amount of air to each burner may be regulated and the direction of flow of this air be slightly oblique to the axis of the cone of oil.

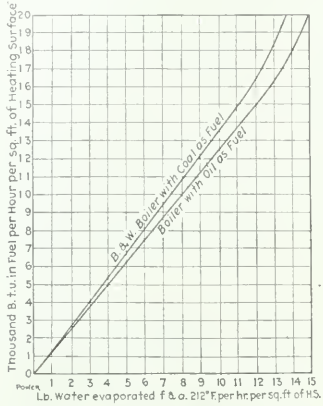
The success of the system depends almost entirely upon the proper handling of the air. Improper air regulation will produce a series of rapid explosions of oil in the furnaces with consequent destruction of the brick linings of the furnaces. With proper handling, the oil burns almost noiselessly, and the amount of smoke produced can be held absolutely under control.

In the first battleships fitted for oil fuel, the oil was only intended as an auxiliary fuel to be used as an aid in keeping up steam when the coal should be so low as to be remote from the firerooms and so require excessive trimming. The results obtained with this mixed system were not good, as the furnace volumes of coal-burning boilers are too small to permit efficient burning of oil. Furthermore, when burning the oil and coal in combination it is impossible to so regulate the air supply that each fuel will obtain the proper amount. This re-

*Excerpt from paper read by Capt. C. W. Dyson, before the Society of Naval Architects and Marine Engineers.

sults in excessive production of smoke and no increase in steam production over coal alone.

To illustrate the value of oil when used as the sole fuel as compared with coal the accompanying chart has been prepared. The two fuels were tried under the same boiler,


Thousand B.t.u. in Fuel per Hour per Sq. Ft. of Heating Surface
B. & W. Boiler with Coal as Fuel
Boiler with Oil as Fuel
Lb. Water evaporated f. & a. 212° F. per hr. per sq. ft. of H.S.

Evaporation with Coal and Oil

the grates being removed after the coal trials and the fronts rearranged to accommodate the burners and air cones.

To compare the relative values from this chart, let a ratio of heating surface to grate surface of 40 to 1 be assumed and a rate combustion of 40 lb. of coal per square foot of grate be taken, the coal having a thermal value of 14,500 B.t.u. per lb. This rate per square foot of grate gives one pound of coal per square foot of heating surface per hour and a supply to the furnace of 14,500 B.t.u. per square foot of heating surface per hour.

From the chart where this value of B.t.u. per hour per unit of heating surface is supplied to the boiler in the form of coal, the consequent evaporation from and at 212 deg. F. per square foot of heating surface will be 10.8 lb. of water. Should this same amount of B.t.u., 14,500, have been introduced into the furnace in the form of oil fuel, the resultant evaporation would have been 11.72 lb. of water.

One pound of oil, however, may be rated at a thermal value of 19,200 B.t.u., therefore the total evaporation per pound of oil would be

$$\frac{19,200}{14,500} \times 11.72 = 15.519 \text{ lb.}$$

against 10.8 lb. per lb. of coal, a ratio of 1.437 : 1, while, if the thermal values of the fuels be compared, the ratio is 1.324 : 1.

The difference between these ratios, in favor of actual evaporative results, is caused by the elimination of all grate losses and losses due to sooting up of heating surfaces when oil is used.

Feed Water Heating and Pumping*

SYNOPSIS—Types and location of heaters, sources of steam and typical layouts. Single direct-acting feed pumps have become the standard. A comparison in steam consumption and weight of direct-acting and rotary pumps.

In the last 25 years the development in marine feed-water heating has merely consisted in the adaptation of design to suit the conditions imposed by varying requirements for different classes of vessels. As regards types of feed heater, there are only two, direct contact and surface. There are also two locations, the first being on the suction side and the second on the discharge side of the feed pump. The heating steam may be obtained from two sources, auxiliary-exhaust and receiver steam, and on these six variants many different arrangements have been devised.

Broadly speaking, direct-contact heaters should be, and generally are, of universal adoption, on account of their simplicity and of the outstanding advantage of their ability to eliminate the corrosive gases from the feed water. Their universal adoption is, however, controlled in lighter draft vessels and in warships, by the necessity of placing them high up in the ship, and also to a slight extent by a disinclination to mix auxiliary exhausts direct with the main feed on account of the suspected boiler troubles due to oil. In large ships where the exhaust of single auxiliaries, such as electric-light engines of considerable power, do contain oil in a considerable amount, this argument is tenable, but when it is considered that almost 5000 vessels are now running satisfactorily with direct-contact heaters, many of them 25 years old, and in addition that there are probably more cases of trouble with oil in boilers on vessels without direct-contact heaters, than with them, some other explanation must be looked for in connection with this difficulty.

As regards location, direct-contact heaters are necessarily always on the suction side of the feed pumps, while surface heaters are most frequently arranged on the discharge side, although not necessarily so. A discharge surface feed-water heater offers the only method of obtaining very high degrees of feed heating over, say, 230 deg. F.

As regards the source of heating steam, the essential principle is to use, in the first place, all the auxiliary exhausts and then supplement from the low-pressure receiver. In earlier days the proportion of auxiliary exhausts to the main feed quantity was low, now it has greatly increased. In ordinary cargo steamers these exhausts will, on the average, heat the feed water through a range of about 70 deg. F., and in some passenger steamers through a range of 90 deg., while in turbine vessels, and especially combination vessels, the range is rendered much higher on account of the increased efficiency of the main installation as compared with reciprocating installations, and also by the additional steam required for independent air and very large circulating pumps, together with the provision of oil-lubricating and water-service pumps. These represent increases on the

*From paper read by William Weir before the Institution of Engineers and Shipbuilders in Scotland.

auxiliary exhaust supply, while for the same power the main feed water itself is decreased.

Diagrammatic sketches of two representative systems were shown. The first was specially applicable to vessels fitted with large electric-light installations where the generators are driven by reciprocating engines of which the exhaust steam contains a certain proportion of oil, and where it is not generally advisable to lead the exhausts from such engines into the same exhaust pipe as the other auxiliaries on account of the fluctuations in pressure. "Dual" air pumps deliver to a hotwell tank, from which an independent hotwell pump draws the water and delivers through a low-pressure surface feed heater to a direct-contact heater. The main feed pumps then draw from the direct-contact heater and deliver to the boilers through the main or auxiliary pipes. The supply of heating steam to the surface heater is the exhaust from the high-speed reciprocating engines driving the electric generators, and the condensed drain water from this heater passes through a gravitation filter to the hotwell tank. The heating steam to the direct-contact heater is all auxiliary exhaust steam, with the exception of the exhaust from the generator sets already mentioned.

The second diagram illustrated an arrangement for large vessels where it is desired to separately filter the whole of the condensed auxiliary exhaust steam before mixing it with the main feed supply. The installation consists of two or more pairs of feed pumps, air pumps, with attached hotwell pumps, low-pressure surface feed-water heater and high-pressure feed-water heater. The air pumps discharge into a self-contained hotwell, from which the hotwell pumps draw and deliver through a low-pressure heater to a float tank. The main feed pumps draw from the float tank in which is contained their control gear, and deliver to the boilers through the feed-water heater, or through the auxiliary feed pipe.

In this arrangement the electric-engine exhausts are led to the low-pressure heater and the remainder of the exhausts to the high-pressure feed heater. A pressure up to 15 lb. may be maintained in the auxiliary exhaust pipes and thus make it possible to heat the feed water through a greater range.

A third sketch, Fig. 1, showed the arrangement used on some recent large war vessels in which feed heating is done in two stages. In a small direct-contact heater of light weight fitted to the feed tank, the feed is raised in

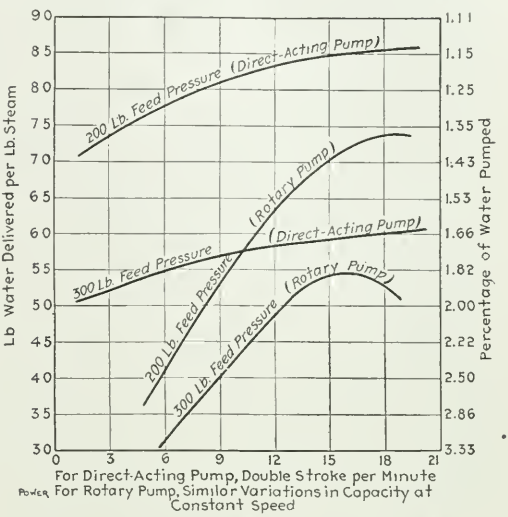

Lb Water Delivered per Lb. Steam
Percentage of Water Pumped
200 Lb. Feed Pressure (Direct-Acting Pump)
(Rotary Pump)
(Direct-Acting Pump)
300 Lb. Feed Pressure
200 Lb. Feed Pressure
(Rotary Pump)
300 Lb. Feed Pressure
For Direct-Acting Pump, Double Stroke per Minute
For Rotary Pump, Similar Variations in Capacity at Constant Speed
POWER

FIG. 2. STEAM CONSUMPTION OF FEED PUMPS

temperature by contact with auxiliary exhaust steam to about 140 deg. F. It is then heated to over 200 deg. F., also by auxiliary exhaust steam in small surface feed heaters placed in the stokeholds and fitted on the feed discharge pipes. The preliminary heating enables a great reduction to be made in the size and weight of the high-pressure heaters.

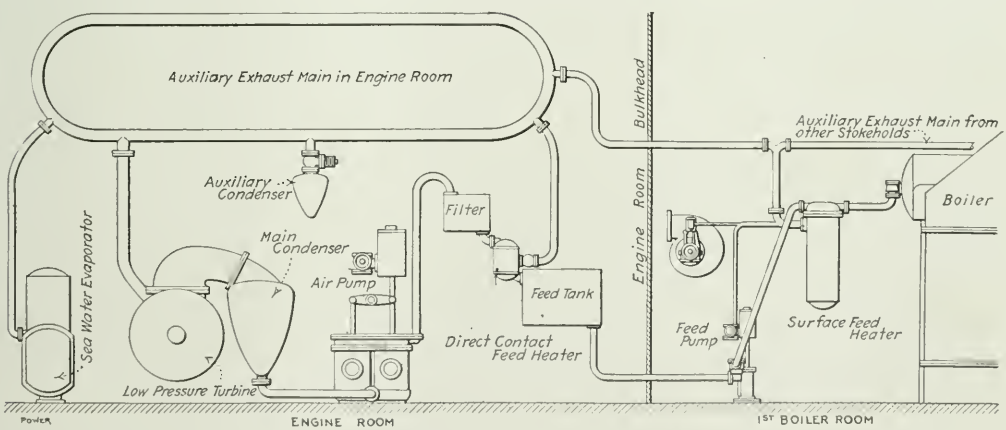


FIG. 1. FEED HEATING DONE IN TWO STAGES

INDEPENDENT FEED PUMPS

A detailed history of the development of the independent feed pump would be largely a recital of endless experiment with and investigation of mechanical details. The difficulty of regulating a crank-driven machine, together with the great and variable stresses, rendered this

type quite inapplicable for high-pressure boiler feeding. Stroke variation and high steam consumption, together with the multiplication of parts, similarly handicap the duplex type. Accordingly the single direct-acting pump has become the standard, and when arranged in conjunction with feed heater or tank float control, this type has become universal in its use.

The general and even the detail design of the pump ends, which at one time varied mainly in their degrees of inefficiency, has now become standardized by almost all makers adopting the same design, and the remaining difference of the many types, apart from workmanship and material, lies in the steam distribution valves.

A point of interest in direct-acting feed pumps is the steam consumption at varying speeds and boiler pressures. Fig. 2 shows a set of curves which represent neither the best nor the worst performances, but which can be taken as representative of actual every-day practice.

During recent years a certain amount of experimental work has been carried out with rotary feed pumps of the centrifugal type, and on the Continent a number of these have been installed in electric power stations. The application of this type of pump to marine use is of great interest, and it is rather unfortunate that the bulk of the experience obtained on shore has been with electrically driven centrifugal pumps. If it were possible, or even prudent, to drive marine feed pumps by electric motors, then it is believed their adoption would be rapid on account of the properties of the electric motor as regards nonvariation in speed, and in this connection it is more than questionable whether electrically driven feed pumps constitute good practice even for electric power stations. On board ship the feed pumps should be driven in every case by the same source of power that actuates the main machinery, and this at once involves the adoption of either a rotary steam engine or a steam turbine in conjunction with the centrifugal pump.

On the steam-consumption diagram for direct-acting pumps, there is also shown the performance of the turbine-driven type, and as will be seen, this type is considerably less economical. In the future this feature may be improved, while as a counterbalancing advantage for certain conditions the weight comparison is given in the accompanying table, which shows the relative weights of direct-acting pumps for different classes of vessels, and discloses a very large possible reduction by the rotary pump.

COMPARATIVE WEIGHTS OF INDEPENDENT FEED PUMPS

Class of Vessel	Feed Pipe Pressure, lb. per sq.in.	Weight of Pump per Hp. of Main Engines
Cargo vessel...	210	0.74
Mail steamer	210	0.72
Channel steamer	210	0.665
Battleship...	285	0.64
Destroyer...	285	0.43
Weir "Rotofeed" Pump..	285	0.14

Guarantees on Steam Generating Units

By T. A. Peebles

SYNOPSIS—The usual method of guaranteeing boiler equipment upon the performance of the whole unit is unsatisfactory, for in case of failure to meet the guarantees it is difficult to fix the responsibility between the boiler, stoker, economizer, draft apparatus, etc. To obviate this the heat balance is recommended.

The purchaser of power-plant equipment wants to know what the manufacturer will guarantee his apparatus to do in actual service and contracts often contain guarantees of capacity, efficiency and repairs. Acceptance tests are run soon after the apparatus is put into operation and the final payment on the purchase price depends upon the outcome of these tests.

The engine or turbine builder guarantees a certain capacity and water rate under stated conditions of steam pressure, moisture or superheat in the steam, and exhaust pressure. The generator man also has a definite basis upon which his guarantee is made and a fair degree of accuracy can be secured on tests.

In the boiler room, the problem is much more complicated and the large number of variables in connection with the boiler test renders it more difficult to secure accurate results. In a modern plant, the steam-generating unit consists of a boiler, stoker, draft apparatus, and probably superheater and economizer. Under the present method of basing the performance of the complete unit on the combined efficiency which is defined as the heat absorbed by the unit per pound of coal divided by the total heat in one pound of coal as fired, a disagreement is almost sure to result among the manufacturers of different apparatus comprising the complete unit in case the test does not meet the guarantee. The guarantee usually specifies that with coal containing stated percentages of moisture, volatile and ash and a certain number of B.t.u. per pound, the guaranteed capacity and efficiency will be developed.

If the capacity falls short, the stoker manufacturer has the excuse that the other parts of the complete unit offer abnormal restrictions to the flow of gases, reducing the furnace draft to a point at which it is impossible to burn the amount of coal required to develop the guaranteed capacity. He may also question the ability of the draft apparatus to take care of a sufficient volume of gases. The other interested parties may take the position that the stoker and furnace are not properly designed to burn the particular coal that is being used and the purchaser is placed in the difficult position of being required to determine just where the fault lies and which part of the unit must be altered to give the desired overall results.

The accurate determination of efficiency is even more difficult. The scales used in weighing coal and water may be calibrated before the test but they are exposed to dirt, water and rough usage during the test and cannot be relied upon to remain accurate unless handled very carefully. With the alternate method of starting and stopping the test, which is almost universally used, it is impossible to estimate accurately the amount of coal in the furnace at the beginning and end of the test. The error thus introduced may be practically eliminated by running a test of at least 24-hr. duration, but long tests are expensive and, in the end, the purchaser bears the expense, as this item is included by the manufacturer in his price.

The source of greatest error is the sampling and analyzing of the coal. If the coal is high in ash and contains some slate and dirt, a difference of 5 per cent. in the B.t.u. of two samples from the same coal pile, as shown by analysis, may easily result. Separate analyses of coal from the same sample may also differ considerably as may be seen from the following table which shows results secured by two well equipped laboratories from coal samples as nearly identical as could be picked by a man accustomed to sampling coal:

	B.t.u. Per Pound			
Sample	Laboratory A	Laboratory B	Difference	Per cent. Difference
1	13,585	14,469	+884	+6.5
2	14,400	14,215	—185	—1.28
3	13,529	13,984	+455	+3.35
4	13,747	14,045	+298	+2.16
5	13,572	14,501	+929	+6.84
6	14,155	14,797	+642	+4.50
7	14,141	13,970	—171	—1.21
8	13,667	14,277	+610	+4.45
9	14,240	13,759	—481	—3.5
10	13,892	14,607	+715	+5.65
		Average..	531	3.9

As stated, these analyses were made in well equipped laboratories and the average percentage of difference represents the probable error in the determination of the heat value of the coal. Laboratory A secured higher heat values than laboratory B on some samples and lower values on other samples, showing that the differences as tabulated are not due to a constant error in the calorimeters used.

When two separate analyses are made of the coal used on an acceptance test, it may happen that the guaranteed results have or have not been secured, depending upon which analysis is used. This usually leads to a difference of opinion which can only be settled by running another test at considerable expense both to the purchaser and the manufacturers.

The heat balance which is coming into general use in analyzing results of boiler and furnace performance affords a more scientific and satisfactory basis for guarantees than the old combined efficiency test. The heat losses, instead of the heat absorbed by the boiler, form the basis for calculating the efficiency and the furnace and boiler losses are definitely separated. The furnace and grate losses are:

1. Heat loss, due to combustible in ash.

2. Heat absorbed by excess air up to the temperature of the steam.

3. Heat loss due to production of CO.

The stoker manufacturer is concerned with these losses only and should not be held responsible for what happens after the products of combustion leave the furnace. He should guarantee to burn a certain amount of coal per square foot of grate surface per hour with a given draft in the furnace, the rates of combustion being given for various draft intensities in the furnace throughout the range of capacity. He should also state the percentage of combustible in the ash and the analysis of furnace gases with which he will effect this combustion.

The boiler losses are:

1. Heat loss due to temperature of the flue gases above the temperature of the steam.

2. Heat loss due to air leakage through the boiler setting.

3. Heat loss due to radiation.

The boiler manufacturer's guarantee should, therefore, specify the flue-gas temperatures for the various rates of combustion given in the stoker guarantee. The draft loss through the boiler for each rate of combustion should also be stated to guard against too close baffling of the boiler in an effort to reduce flue-gas temperatures. The loss due to leakage through the setting can be determined by comparing an analysis of the flue gases at the boiler damper with the analysis of the furnace gases, and the boiler guarantee should state the analysis at the damper after knowing the guaranteed analysis at the furnace. The loss due to radiation cannot easily be determined, but if the boiler walls are of sufficient thickness, careful inspection while the brickwork is being set, will give assurance that this loss is not excessive. The boiler guarantee should specify the percentage of moisture in the steam at different rates of combustion.

With the information contained in furnace and boiler guarantees, the manufacturers of economizers and superheaters can intelligently determine and state the performance of their apparatus. Each manufacturer of apparatus going into the complete unit should be advised of the guarantees of the others, particularly as to draft losses. The draft apparatus must provide sufficient draft intensity to overcome the losses of all apparatus in the path of the gases and still provide the required draft in the furnace and must be of such capacity that it can maintain this draft intensity when handling the volume of gases resulting from the combustion of the maximum amount of coal to be burned.

The foregoing method of stating guarantees clearly defines what each part of the unit must do and enables the man in charge of a plant to determine who is responsible in case the overall efficiency is low. It prevents the shifting of this responsibility which may occur if all the apparatus comes under one general guarantee and it also establishes standards of draft, flue-gas temperature and flue-gas analysis which give the operating engineer a simple and accurate means of determining what his boiler and furnace equipment is doing.

The Sarco Automatic Grease Lubricator

This lubricator is made in two types, one actuated by a pendulum, for moving bearings, such as crossheads, cranks, etc.; the other actuated by clockwork in a dustproof casing and used for stationary and slow moving bearings. Both lubricators feed grease in the same manner.

In the pendulum type, the pendulum, instead of a spring, actuates the clock movement and consequently when the bearing stops moving the pendulum the feeding of the grease stops simultaneously.

The body of the cup is of gun metal and screws to the bearing. Grease is pressed down into the bearing by a piston, operated by the clockwork, which is placed in a hermetically sealed casing. The speed of the piston depends on the thread of the spindle, six different sizes being provided to suit various conditions.

The clock is wound up daily. If more grease is delivered than required the clock stops automatically. It restarts as soon as the bearing requires lubrication. A lever on the cover of the lubricator releases and stops the clock. These lubricators are manufactured by the Sarco Engineering Co., 116 Broad St., New York City.

ELECTRICAL DEPARTMENT

Protective Relays

By H. R. Stickney

The purpose of protective relays is to protect the system from the destructive effects of short-circuits, excessive overloads, excessive voltage, reverse currents, etc. A number of different types are on the market, but, as they all operate on very much the same principle, only the three most important types will be discussed. These are the instantaneous, the inverse time-limit and the definite time-limit relays.

The instantaneous relay is designed to operate at a predetermined current value, usually the limiting capacity of the apparatus. It consists of a solenoid, the plunger of which carries at its upper end a device for closing or opening an independent circuit, which in turn will open or close the oil switch or circuit-breaker on its respective circuit. The current value at which these relays will operate is determined by setting the height the plunger will have to rise to close its relay contacts. This is done by a small thumb-screw at the bottom of the plunger casing, which by turning, lowers or raises the plunger.

A series transformer is used in connection with these relays to control the current in the relay itself, for it would be impractical to have the total line current pass through the relay. The primary of these transformers consists of one straight bar about which the secondary is wound, the primary being connected in series with one phase of the feeder; see Fig. 1. The secondary, as stated, is wound upon the primary, the number of times bearing any desired ratio to the primary. Since there is no iron present in the transformer, this ratio will remain practically constant at all loads.

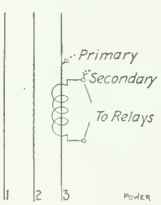


Fig. 1. Transformer

In a transformer having a ratio of 50:1, only $^1/_{50}$ of the current in the feeder would be induced in the secondary and flow through the relay. Most relays are graduated for from 5 to 10 amp. for their operation and assuming this basis, suppose it is desired to open a feeder when the load reaches 250 amp. Since the transformer ratio is 50:1, the current passing through the secondary to the relay would be

$$\frac{1 \times 250}{50} = 5 \ amp.$$

And at this value the relay would be set to operate.

The usual method of protecting a three-phase system is by using two relays and their respective transformers connected as shown in Fig. 2. The ground connection shown is so placed on the common return wire that it may act on both transformers, its purpose being to protect the operator, instruments and relays from the high potential of the feeder if the insulation of the transformer should break down.

Now consider the operation of the system. If phase No. 3 should become overloaded, transformer *A* would

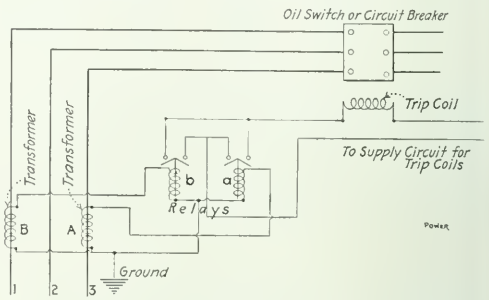


Fig. 2. Three-phase System with Two Relays

respond, causing relay *a* to operate and close its respective circuit tripping the coil of the circuit-breaker. Similar action would take place in case phase No. 1 were overloaded. The trip coils are usually wound for 125 volts at 5 or 10 amp. and are operated from storage batteries or other independent low-potential sources.

The inverse time-limit relay is similar to the instantaneous relay, with the exception that at the contact end of the plunger is placed a small bellows fitted with an adjustable air-valve. As the plunger rises its speed is retarded, due to slowly forcing out the air in the bellows through the air valve. The heavier the overload, the greater the force spent upon the bellows and therefore the air is expelled at a grater rate, allowing the contacts to close more quickly; that is, the time of closing varies inversely as the magnitude of the disturbance—hence, the name "inverse time-limit relay."

The definite time-limit relay is similar except that between the bellows and the plunger is interposed a small spring which is acted upon, giving a definite period of time which varies directly with the adjustment of the air valve at the top of the bellows. Some makers use a gravity accelerated dashpot with a similar air valve; this depends upon the plunger to allow the contact rod to drop by its own weight upon release. The speed at which it descends is governed by the air valve in the dashpot.

Those types of relays explained are known as circuit-closing relays, i.e., closing the trip-coil circuit. There is another type, known as circuit-opening relays, operating the trip coils by deënergizing their respective magnets. Also, reverse-current relays are often used on direct-current generators and rotary converters to prevent a flow of current into the machines from the line.

Obtaining Wire Resistance on Slide Rule

By A. F. Moore

A very useful and easily remembered method of ascertaining the resistance of copper wire with an ordinary slide rule is as follows:

Looking at the back of the rule, set the last digit of the B. & S. gage number of the wire on the logarithmic or middle scale of the slide, opposite the hair line on the right. Turn the rule face up and read the number on the bottom or "D" scale opposite the 1 at the left end of the slide. To point off, remember that the resistance of wire from No. 0 to No. 10 is of the order of tenths, No. 10 to 20 is of the order of units, No. 20 to No. 30 is of the order of tens, etc. The result will be a very close approximation in ohms per 1000 ft. of copper wire of the size required, at 20 deg. C. With No. 11 B. & S. gage the result is exact, and the error varies from about 2 per cent. high for No. 0, to 4.5 per cent. low for No. 40. This is accurate enough for ordinary calculations. To obtain the result for No. 00, No. 000 and No. 0000, consider No. 00 as No. 9, No. 000 as No. 8, etc., and set the decimal point one more place to the left.

As an example, let it be desired to know the resistance of 1000 ft. of No. 15 B. & S. copper wire. Looking at the back of the rule set 5 on the logarithmic scale on the middle of the slide, opposite the hair line on the right-hand end of the rule. Turn the rule face up and read 3161 on the lower scale, opposite the 1 at the left end of the slide. Since No. 15 comes between No. 10 and No. 20, the resistance will be of the order of units, or 3.161 ohms per 1000 ft. If the wire had been No. 5, resistance would have been 0.3161; if No. 25, 31.61, etc.

Synchronous Motors Driving Air Compressors

The use of the synchronous motor, because of inherent advantages for certain kinds of service, is now becoming more extensive. As applied to driving air compressors, an interesting installation is to be found at one of the Central Park shafts of the tunnel which is being driven under New York City in connection with the Catskill aqueduct system.

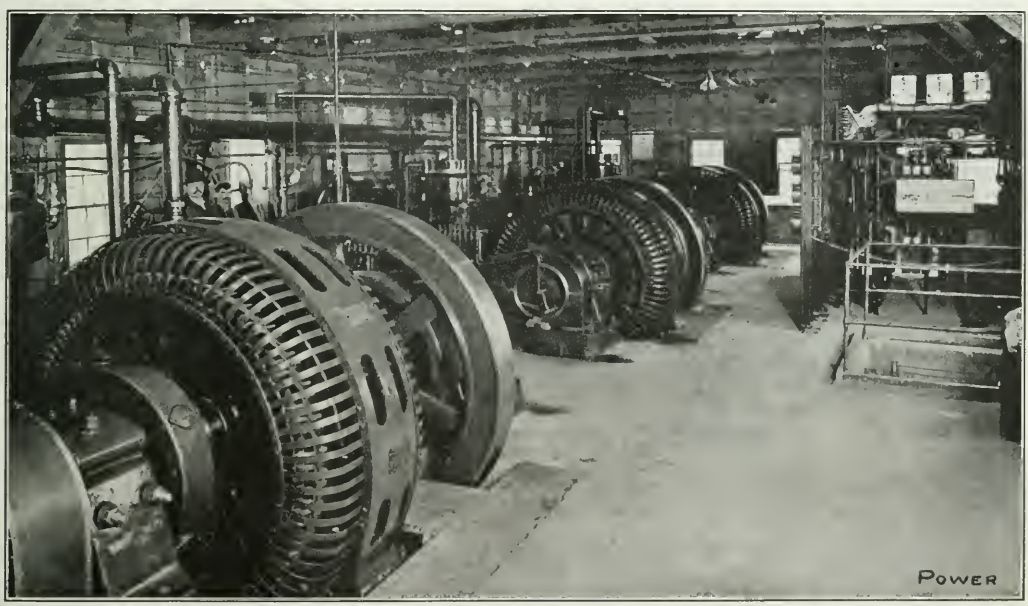
The plant, as shown, consists of three two-stage Sullivan air compressors, each coupled direct to a 400-hp., 6600-volt, three-phase, 25-cycle Westinghouse synchronous motor. The compressors furnish air for driving air drills. They are each 15½x20x18 in. and have a piston displacement of 2070 cu.ft. of air per min. at the rated speed of the motor, 187½ r.p.m.

A vertical intercooler with copper water tubes, placed between the high- and low-pressure air cylinders, provides 10.75 sq.ft. of cooling area per 100 cu.ft. of free air.

The volume of air delivered is made proportional to the demand by means of a double-beat unloading valve on the air inlet of the intake cylinder. This valve is either fully open or tightly closed, so that there is no choking effect on the entering air. A 3½-ton flywheel renders the operation of the outfit smooth and eliminates any objectionable peaks in the power-consumption curve.

A particular advantage of this type of motor is that, in addition to its use as a motor, it may be employed as a synchronous condenser to improve the power factor of the circuit, this being accomplished by adjusting the field excitation.

Direct current at 125 volts is furnished for the field excitation by an exciter mounted on the compressor frame



Synchronous Motors Driving Air Compressors at Aqueduct Shaft

and driven by a belt from the crankshaft. The revolving portion of the motor is provided with a combined starting and damper winding so proportioned that the necessary starting torque is developed by the minimum line current, consistent with the synchronous operation. This starting winding is similar in construction and operation to the rotor winding of the well known squirrel-cage induction motor. Tests have shown a power consumption of 345 cu.ft. of air per kw.-hr.

Incidentally it may be mentioned that the water for this great system is to be brought all the way from the Catskills in an underground tunnel which at Storm King crosses under the Hudson River at a depth of 1100 ft.

The water is to be carried from Ninety-ninth St. to Fourteenth St., Manhattan, a distance of 4.38 miles, in a tunnel cut through solid rock its entire length, about 225 ft. below the level of the street. It has a finished bore of 14 ft. inside the concrete lining down to Forty-second St., 13 ft. to Twenty-third St., and 12 ft. from there to Fourteenth St.

The six shafts sunk are located as follows: Three in Central Park, at Ninety-third St., Eighty-first St., and Sixty-sixth St.; one at Fiftieth St. and Fifth Ave.; one at Forty-second St. and Bryant Park; and one at Twenty-fifth St. and Broadway.

Signal System

In power plants where the generators are located some distance from the switchboard some reliable system of signals between the engineer and the switchboard operator is necessary. The following is a description of the system I have installed in connection with one of our 1500-kw. units.

I first made an 18x10x6-in. box of wood lined with asbestos and divided it into six compartments in each of which was mounted an 8-cp. lamp. On a piece of tracing cloth just large enough to cover the front of the box the signals were painted so that one signal would be over the lamp in each compartment. The signals were: "On," "Off," "Slow," "Fast," "Coming On" and "Coming Off." This box was mounted on top of the gage board where it could be plainly seen by the man at the engine throttle.

On the generator oil switch were mounted two contacts connected to the signals "On" and "Off"; a pull-and-push switch normally open was mounted on the generator panels and connected to the signals "Slow" and "Fast." Just below the synchronizing plug receptacle was mounted a single-pole double-throw knife switch, so mounted that in the up position the handle prevented the plug from being inserted. This plug was connected to the signals "Coming On" and "Coming Off," so that in throwing down the switch the engineer is notified that the operator is ready to synchronize. A lamp was also mounted on the signal box and connected to the synchronizing busbar, which permits the engineer to bring the engine to proper speed by watching the pulsations of the lamp. The operator signals if slow or fast and as soon as the oil switch is closed the signals "Off" and "Coming On" go out and the signal "On" shows up.

In shutting down the generator the operator puts the single-pole switch up and this shows the signal "Coming Off. The engineer then begins to slow the engine and as soon as the oil switch is opened the signals "On," "Coming Off" go out and the signal "Off" shows up. The operator is compelled to notify the engineer before he can synchronize.

This system has been in operation here several months and is reliable and practically fool-proof and is very valuable where the engine speed is controlled by the man at the throttle.

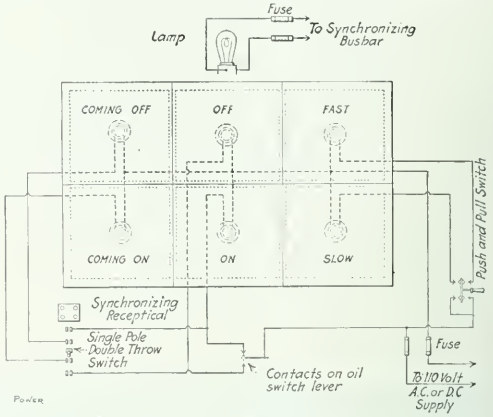


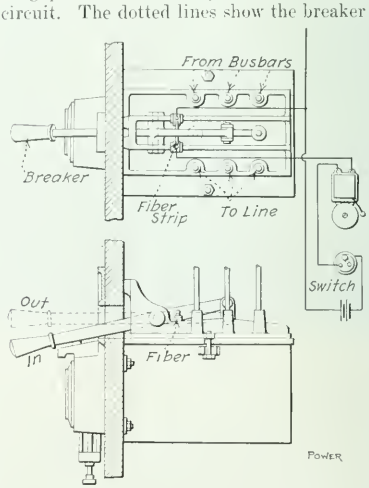
Diagram of Signal Connections

William R. Davis.

Springfield, Ill.

Oil Circuit Breaker Alarm

The sketch shows a simple alarm for oil circuit-breakers, it being possible to put any number of breakers on the one circuit. The dotted lines show the breaker out, in which position the metal of the breaker makes contact with the brass, fiber-insulated strips and closes the alarm circuit, thus ringing the bell. A small switch is necessary in the bell circuit as sometimes certain breakers are not required in service.



Alarm Circuit Connected to Oil Switch

James A. Campbell.

Providence, R. I.

GAS POWER DEPARTMENT

Test of Gas Producer Plant

By L. L. Brewster

The economy of a gas-power station under normal and commercial operating conditions is shown in the appended data from a five weeks' test. The owners of this plant desired to know just what results were being obtained in the gas-power plant which was installed about three years ago, and for a period of five weeks carefully measured all the necessary quantities for securing the desired information.

The plant under discussion is thoroughly modern, equipped with apparatus of approved design and operated by an engine and producer-room crew which are well above the average. The equipment consists of two bituminous producers of 250 hp. each; three double-acting tandem gas engines direct connected to 100-kw., three-phase, 60-cycle, 500-volt generators. The exciter for each generator is belt driven from a pulley on the engine shaft just outside the outboard bearing. Two or three of the units operate in parallel whenever desired, delivering current to a single set of busbars. During the five weeks' test period it was necessary to run only two engines part of the time and one engine the rest of the time; thus the third engine was, during this period, a spare unit. The producers are each pulled by a rotary exhauster which also serves as a centrifugal scrubber, the gas first passing through a static scrubber and cooler. The exhausters deliver their gas through a common main to a small holder whose capacity is too small to make it of service except as a pressure regulator. It is so weighted that gas reaches the engines at about atmospheric pressure or slightly above.

During the test period the load on the engines was frequently a maximum for short periods and this made it necessary to run two engines, although, as shown by the data, the average load per engine was slightly over one-half its rated capacity.

The fuel consumption noted is the total for the period and therefore includes the consumption during standby periods as well as during periods of operation. An analysis of the data given will show that the load-factor for the entire period was comparatively small. The producer plant delivered gas for the engines under load for 507¼ hr. out of a possible total of 840, or 60.4 per cent. of the time; the standby period was, therefore, nearly 40 per cent. of the total time. In the 29 days of running the engines ran a total of 565 engine hours and developed 31,592 kw.-hr. at the switchboard. At their rated capacity they would have developed during this period 56,500 kw.-hr., so that the load-factor was about 56 per cent. The total capacity of the three engines would be 7200 kw.-hr. per day of 24 hr., or 208,800 kw.-hr. for the 29 days' run, or a loading factor of about 15 per cent.

The summary of the test shows the fuel consumption per kilowatt-hour for the entire period to be 3.08 lb., and for the last two weeks of the test 2.93 lb. These figures should be considered only in connection with the conditions of the run which show that the average load on the engines for the time they were run was only slightly over one-half load, and a total standby on the producers of nearly 40 per cent. of the time.

The consumption stated is for the net power delivered to the switchboard, which, of course, does not include that necessary to drive the exciter units. This net power is not all available, however, for distribution to the factory, for about 10 per cent. of it is used for driving the rotary scrubbers and the centrifugal pumps for circulating cooling water to the engines.

Table 1 is a summary of the principal results in the producer operation for the entire test period. Table 2 is a sample log of a week's run. In Table 3 is shown the

TABLE 1. SUMMARY OF FIVE WEEKS' TEST ON GAS PRODUCER

	Gas Registered by Meter	Gas Corrected to 60 deg. F.	Fuel Used in Coal Equiv. (Lb. of coal =0.875+Lb. of Coke)	Gas per Lb. of Fuel Corrected to 60 Deg. F.	Average Fuel per Day, Lb.	Producer Hours	Total Kw.-hr. at Switchboard
Week.. Aug. 26-31, 6 days	1,478,000 25,600 (Used at dryer metered separately	1,399,818 25,000	14,780 (coal) 2,450 (coke) 16,924 (total fuel)	96.4 (coal) 84.2 (fuel)	2,463 coal 409 coke	98½	4,620
Week.. Sept. 3—7, 5 days	1,452,400	1,368,412	14,233 (coal) 1,313 (coke) 15,382 (total fuel)	96.1 (coal) 89.0 (fuel)	2,486 coal 239 coke	100	5,260
Week.. Sept. 9—14, 5 days	1,569,600	1,468,417	17,737 (coal) 1,312 (coke) 18,885 (total fuel)	82.6 (coal 77.8 (fuel)	2,964 coal 239 coke	98½	5,321
Week.. Sept. 14—21, 6 days	Meter stopped on Sept. 19, repaired Sept. 22	2,028,000 (calculated using 251 cu.ft. per kw.)	19,947 (coal) 2,275 (coke) 21,938 (total fuel)	101.7 (coal) 92.4 (fuel)	3,325 coal 379 coke	99	7,890
Week.. Sept. 23—28, 6 days	2,197,200	2,088,278	22,118 (coal 2,275 (coke 24,109 (total fuel)	94.4 (coal) 86.6 (fuel)	3,686 coal 379 coke	111½	8,510
Totals		8,377,925	88,815 (coal) 9,625.(coke)			507¼	31,592
	On first 3 weeks siderable gas was blasted up the stack in order to keep the fires in the producer hot, especially on Sept. 9—14. This gas could not be metered.	Average fuel per kw.-hr. during whole test, test 3.08 lb.	Average fuel per kw.-hr. during last two weeks 2.93 lb.	All B.t.u determinations and analyses were made from gas taken from the holder. Gas passing from the producer to the holder showed a much greater fluctuation.			

gas consumption of the engines for a week's run, and Table 4 is a record showing the variation in gas quality for a considerable period of time during one day, and also shows a sample gas analysis and an engine exhaust analysis.

The gas was also sampled for determination of the quantities of tar and dust and an average of all the samples taken showed that there was no tar present in the gas, but there was a dust content of 0.044 gr. per cu.ft., the sample being taken at the scrubber outlet. A computation of the amount of sulphur in the gas showed that the gas contained 0.001 per cent. of sulphuretted-hydrogen (H_2S). This computation was made on the assumption that one-half of the total sulphur in the coal was gasified and that the sulphur content of the coal was 1.2 per cent., as shown by the analysis.

The reader should bear in mind that these results were obtained by simply measuring the necessary quantities for a period of five weeks, during which time conditions were simply those demanded of the power plant in supplying electric power to the factory in which it is situated. Under favorable conditions this plant has, to the writer's knowledge, developed a brake horsepower-hour on slightly less than one pound of coal, such as was used in this test. The effect of the load-factor and the loading factor in this particular case is to increase the fuel consumption to about twice this amount.

TABLE 2. LOG FOR WEEK'S RUN

Date	Producer	Engine, hours run	Gas pressure, inches of water	State of meter	Actual gas psased, cu.ft.	Corrected gas passed, cu.ft.	Hours run for producer	Gas per hour	Coal per hour, average lb.	Coal for week, lb. coal	Cu.ft. gas per lb. coal	Total kolowatt hours	Remarks
Sept 23.	No 1	Nol 1– 9¾ No. 3–10¾	4 4	At start 6 a.m. 5,831,100 cu.ft. At end 4.30 p.m. 6,100,500 cu.ft.	269,400	260,394	11¼	22,643	199.8	22,118 2,275 (coke)	94 44 86 6 (with coke)	1080	No slow downs Very cloudy Humid
Sept. 24	No. 1	No 1– 9¾ No. 3–16¼	4.4	At start 6 a.m. 6,100,500 cu.ft At end 12 m. 6,433,700 cu.ft	343,200	327,567	16¼	20,158				1370	No slow downs Rain
Sept. 25.	No. 1	No. 1– 9¾ No. 3–22¾		At start 12 m. 6,443,700 cu.ft. At end 12 m. 6,849,700 cu.ft.	406,000	384,226	22¼	17,077				1620	No slow downs Rain unitl 12 m.
Sept. 26.	No. 1	No.1– 9¾ No. 3–22¾		At start 12 m. 6,849,700 cu.ft. At end 12 m. 7,255,200 uc.ft.	405,500	383,753'	22¼	17,056				1600	No slow downs Clear
Sept 27	No. 1	No.1–13¾ No. 3–18¾		At start 12 m. 7,255,200 cu.ft. At end 12 m. 7,682,100 cu.ft.	426,900	404,004	22¼	18,157				1610	3 min. interruption No. 3 engine stopped on night run. Rain in a.m. Clear inp.m.
Sept. 28..	No. 1	No. 1–11¼ No. 2–14¾		At start 12 m. 7,682,100 cu.ft. At end 4. 30 8,028,300 cu.ft.	346,200	328,333	16½	19,900	Had to shoot fire 8 times today to capacity of 2 engines, maximum vacuum 15 inches			1230	No slow down Clear
Total.....					2,197,200	2,197,200	2,088,277	111½				8510	

TABLE 3. GAS CONSUMPTION OF ENGINES

		Cu.ft gas at 60 deg. F.	Total kilowatt hours at Switchboard	Cu ft gas per kw.-hr. at 60 Deg. F.	Kilowatts per Engine-hour	Remarks
Sept. 23.	Day	260,394	1,080	241 1	54 7	
	Night	Did not run	0	0	0	
Sept 24.	Day	264,855	1,070	247.5	54 2	
	Night	138,211	530	260 8	44 1	
Sept. 25.	Day	245,538	1,080	227 3	54.0	
	Night	142,596	540	267 8	45.0	
Sept. 26	Day	239,582	1,060	226.0	53.0	
	Night	143,834	530	271.4	44 1	
Sept. 27.	Day	252,572	1,060	238 2	53.0	3 min. interruption due to engine No. 3 off line on night run.
	Night	158,820	540	294 1	46.0	
Sept. 28.	Day	249,673	1,020	244 8	51 0	Shot fires eight times to allow capacity of exhauster to give sufficient gas for two engines for this day's run. Maximum vacuum 15 in.
	Night	Did not run	0	0	0	
Total.		2,096,075 2,088,278	8,510			22,118 lb. coal per week 2,275 lb. coke per week 2.60 lb. coal per kw.-hr. 0.27 lb. coke per kw.-hr.
Aver				246.0	49.91	
		Disparity in figures is due to a slight difference in conversion factors for each day. Uncorrected gas 2,197,200 cu.ft. registered on meter.				Two engines on during day only. One engine on during night.

TABLE 4 GAS QUALITY AND ENGINE EXHAUST COMPOSITION.

Sept 13. 1912.

Time	B.t u. at 60°F.	Gas Analysis — 10 10 a.m.	Per Cent.
7:00	87 5	CO_2.....	8.0
7:15	91 8	O.....	0.2
7:30	101 0	CO.....	17.0
		CH_4	0.8
8:00	100 5	H.....	13.5
		N	60.5
8:15	99 1		100 0
8:30	103 3	Exhaust from engine No. 2.	
9:00	110 1	1 p.m. 1:35 2:05 2:45	
9:30	109 3	CO_2 .. 14 0 12 0 12 5 15 2	
		O .. 4 0 4 4 5.7 3.0	
10:00	106 9	CO.. 0 0 0.0 0 0 0.0	
10:30	105 0		
11:00	106 4	Eureka coal analysis:	Per Cent.
11:30	103 4	Moisture	1.47
		Volatile matter	13 70
12:00	101 8	Fixed carbon.....	76.94
		Ash.....	7 89
12:30	101 4		100.00
1:00	110.3	Sulphur.....	1.2
1:30	108.0		
2:00	105 1		
2:30	106.5	Blasting up stack until 10 a.m.	
3:00	106.5		
3:30	107 7		
4:00	110.7		
4:15	110 3	Average—104 3 B.t.u. per cu.ft	

⁂

Operating Results with Diesel Engine

As a great deal is known about the construction of Diesel engines but not so much about operating results in actual practice, the following extract from a report of the engineer-in-chief of the Hamburg-American liner "Christian X," about his experience on the first trip from Hamburg to Havana will be of interest. The report says:

"The pistons and cylinders of the main engines have given no trouble, but it will take another 10 or 15 days before the inner surfaces are quite polished, whereupon it is hoped to reduce the lubricating-oil consumption from 26 to 23 lb. per 24 hr. Heavy, dry deposits were found on the pistons and cylinder interiors, due probably to the high ash and sulphur content of the fuel oil used. All the exhaust valves had to be exchanged after the voyage

was completed, as they showed deep grooves at the tapered seats, which are very likely due to the same cause. Nearly all the valves and seats must be reground. The tanks containing compressed air for the fuel injection had to be emptied every two hours of water which accumulated, as the atmosphere contains considerable moisture. Closing against a pressure of 60 atmospheres the valves—admitting compressed air from the tanks—can only be opened slightly. But the severe throttling which thus results causes leakage of these valves after some time. This could be avoided if a second valve were interposed, which effects the throttling, while the first named valve on the air tank is opened to the full extent. All bearings, as well as the guides, of both engines were carefully inspected but no appreciable wear was found.

"Between July 26 and 27, a trial run of 24 hr. took place, during which the two main engines as well as the auxiliary compressor were indicated every 4 hr. The following data were obtained:

"Output of the two main engines, 2383 i.hp.; fuel consumption of these engines, 8.5 tons in 24 hr., or 0.32 lb. per i.hp.-hr. The capacity of the auxiliary compressor was 216 i.hp., and its fuel consumption in 24 hr. 1848 lb., or 0.35 lb. per i.hp.-hr. The total fuel consumption for the main and auxiliary engines amounted to 9.3 tons in 24 hr., or, referred to the output of the main engine, 0.36 lb. per i.hp.-hr.

"During the whole journey the main and auxiliary engines worked satisfactorily and without interruption, and the exhaust of all engines was free from soot."

CORRESPONDENCE

Trouble with Gas Meter

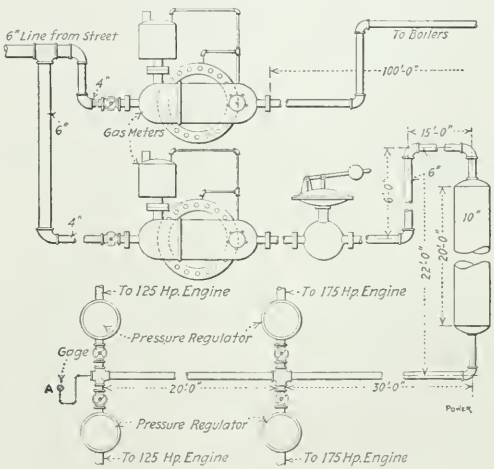
Our power plant in a large office building, consists of four gas engines amounting in all to 600 hp., which furnish all the light and power. Two 54 in. x 16 ft. fire-tube boilers are used for heating only.

Two of the engines are run during the day time and one at night; one boiler is fired at a time and that only in winter . As will be seen by the accompanying sketch our gas supply comes from the street through a 6-in. line, inside of the building it branches off into two lines each 4-in. and leading to two 4-in. gas meters, each meter having a rated capacity of 10,000 cu.ft. per hr. One meter is on the gas engine line and the other on the boiler line. The boiler line continues with a 4-in. pipe to the boilers, with 100 ft. of pipe between the meter and the boilers.

The gas engine line after leaving the meter leads to a 4-in. pressure reducing regulator, after passing which it is increased to 6 in. for 25 ft., and then opens into a 10-in. manifold 20 ft. long; from the manifold it is again reduced to 6 in. for a distance of 30 ft. Off from the last 20 ft. the connections for the four engines are made. Each engine has its own pressure reducing regulator which reduces the pressure from 6 oz. to that of the atmosphere.

The two engines (one 125 hp. the other 175 hp.) that run each day do not at any time carry over 75 per cent. of their rated load. The consumption of gas by the engines in 24 hr. average from 12,000 to 16,000 cu.ft. and the highest hourly rate does not exceed 3000 cu. ft. per hr. The highest consumption on the boilers seldom goes above 60,000 cu.ft. in 24 hrs. on a very cold day, while it generally ranges from 30,000 to 50,000 cu.ft. according to the weather. The line pressure at the meters is 8 oz., the regulator on the engine line is set for 6 oz. and at any time when two or even three engines are running the gage A at the end of the engine line always shows 6 oz., and never indicates any fluctuation in pressure on the line.

Yet the gas company repeatedly complains that the gas engines strain its meters and that it has to change them oftener than on the boiler lines.



Connections to Engines and Boilers

I have never been able to understand this as the meters have a capacity of four to six times the amount used, and the gas pressure is always up to standard. If the pressure occasionally dropped so that the engines would pump the gas, there might be a cause, but with the pressure always up I cannot find an explanation of the difference. The only answer obtained from the gas company is that its meters on gas engines when brought into the repair shop are in worse condition than any others which it has in service.

L. M. Johnson.

Emsworth, Penn.

Gas Engines in Pittsburgh Hotel

Three 150-hp. Bruce-Macbeth engines have just been installed in the Fort Pitt Hotel, Pittsburgh. Each engine is direct connected through a link coupling to a 100-kw., three-wire, direct-current generator, and is to run in parallel with steam units previously installed. The engines are equipped with double-magneto igniters and with gas-economy indicators, which shows instantly the consumption of gas per kilowatt-hour for each engine independently.

Power from this plant is used for both elevator and lighting service and for some twenty motors for various purposes about the hotel.

HEATING AND VENTILATION

Use of Pitot Tube in Air Measurements

By Frank L. Busey

There are a number of methods used to measure the velocity or volume of a current of air, depending on conditions, such as the object of the test, the degree of accuracy desired, or the general arrangement of the installation. For many purposes, such as measuring the velocity of the air leaving a register, the anemometer will answer. For fan testing or for determining the quantity of air flowing through a system of ducts or piping, the pitot tube is more accurate and is easy to manipulate. That it is not more extensively used is probably due to the fact that it is not more generally understood.

Operation and Form of Tube

The pitot tube is an instrument used for making velocity measurements of a current of air, the principle of its action being shown by Fig. 1. When there exists through a system of piping a flow of air, due to a certain pressure, a part of this pressure, termed the "velocity head" or "velocity pressure," is transformed into velocity, while the balance, termed "static head," serves to produce pressure. The sum of these two make up the total head or pressure, also frequently referred to as "dynamic head."

Either the total pressure or static pressure may be read from a gage, but the velocity pressure is determined indirectly. If a bent tube with an open end be inserted in an air duct, as at *B* in Fig. 1, with the open end facing the air current, a pressure, due to both the velocity and static head, will be produced in this tube. This is the total or dynamic head, and the amount can be read on an attached gage or manometer tube. If instead of a bent tube, a straight tube be inserted, as at *A*, the difference in levels in the manometer tube will indicate the static head or pressure. The velocity head or pressure may then be determined by subtracting the static from the total manometer reading.

The pitot tube as ordinarily used is an instrument combining the two tubes just described, as shown at *C*, the outer ends being connected to the two legs of the same manometer. By this means the subtraction is made automatically and the difference as shown by the gage is due to velocity pressure only. These tubes are usually combined in some such form as shown in Fig. 2.

Great care should be taken to keep the tube fixed in a position exactly parallel to the direction of flow, as only when in this position will the reading be correct; it should be pointed against the direction of flow. A convenient form of gage for use with low pressures is the ordinary Ellison differential draft gage. The pressure may be read either in inches of water or of mercury.

Theory of Pitot Tube

This is thoroughly discussed by Frank H. Kneeland, together with a study of some of the different forms, in a paper read before the American Society of Mechanical Engineers, in December, 1911. Having determined the velocity head as above explained, the actual velocity may be calculated by means of the formula.

$$V = \sqrt{2gh}$$

where

V = Velocity in feet per second;
g = Acceleration due to gravity in feet per second;
h = Velocity head in feet of air.

Let V_1 = velocity in feet per minute. Then

$$V_1 = 60\sqrt{2gh}$$

The value of h in the above formula is expressed in head of air in feet, whereas the measurements taken are

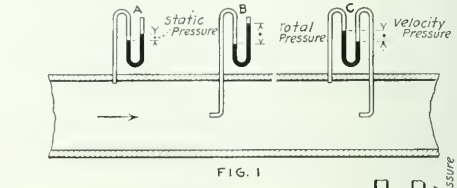


FIG. 1

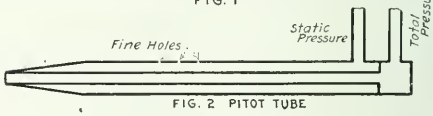


FIG. 2 PITOT TUBE

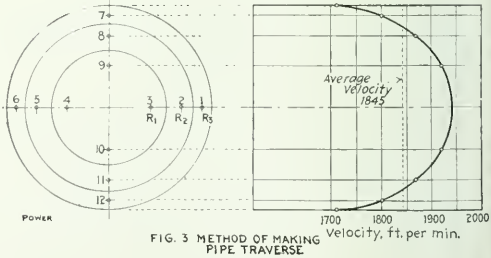


FIG. 3 METHOD OF MAKING PIPE TRAVERSE

ordinarily h_1 = head of water in inches as read on the manometer. Letting w = weight of air per cubic foot and d = density of water in pounds per cubic foot, gives

$$V_1 = 60\sqrt{\frac{2gh_1d}{12w}} = k\sqrt{h_1}$$

With air at 70 deg. and 29.92 in. barometer, $d = 62.31$ and $w = 0.07494$, whence the above formula becomes

$$V_1 = 60\sqrt{\frac{2 \times 32.16 \times h_1 \times 62.31}{12 \times 0.07494}} = 4005\sqrt{h_1}$$

From this it may be seen that the velocity at 70 deg. and 29.92 in. barometer, due to 1-in. pressure, is 4005 ft. per min., and the velocity at any other pressure may be determined from the above relation. That is, the velocity varies as the square root of the pressure. For any other temperature or barometric pressure the velocity may be

found by inserting the proper values of d and w in the above formula, or from the ratio of the absolute temperature or barometric pressure, since at constant pressure the velocity will vary directly as the square root of the absolute temperatures or inversely as the square root of the barometric pressures. Table 1 gives the velocity at various pressures for air under standard conditions of 70 deg. F. and 29.92 in. barometer.

These formulas may be considered sufficiently accurate for ordinary velocities, say up to 6000 ft. per min. Above that velocity and for very accurate work, various corrections should be made. These corrections, based on the experiments of Capt. D. W. Taylor, are discussed by Mr. Kneeland in the paper already referred to.

Use of Pitot Tube in Air Duct

For fan testing or in ventilation work the pitot tube may be used to determine the velocity, and hence the quantity, of air flowing through a duct or pipe. The tube should be inserted at a point where the duct is straight and the flow undisturbed. In testing a fan the pitot tube should be placed from 10 to 20 diameters from the fan outlet with the point directly facing the blast. The air pipe should be the same diameter as the fan outlet.

The velocity pressure shown with the tube in the center of the duct, will be higher than the average, and will vary at different points from the center to the sides of the duct. To obtain the true or average pressure it is necessary to multiply the velocity pressure reading obtained at the center by the proper coefficient. Various authorities give a coefficient of from 0.87 to 0.91 for circular pipes, but the results of careful experiments show that a coefficient of 0.89 for square and 0.90 for round pipes will give the true average velocity pressure when readings are taken at the center of the pipe or duct. Fairly accurate results may be obtained by multiplying the velocity at the center of the pipe by 0.95 to obtain the average velocity.

For more accurate work it is better to make a traverse of the pipe and either determine the coefficient for the case in question or take the average of all of the readings. Where the duct is rectangular it may be divided into a number of small squares or rectangles and a reading taken in the center of each. Then the average of all of the velocities corresponding to these pressures will give the true velocity in the duct. In case the pipe is round, its area should be divided into a number of concentric zones or rings of equal area, and four readings taken in each area, readings being taken horizontally and vertically across the pipe.

The position of each successive point may be found by dividing each ring into two equal areas and adding one of these to the sum of the preceding areas. The radius of this resulting area will locate the desired point.

Expressed by means of a series of formulas, these points may be found as follows:

$$R_1 = \sqrt{\frac{a}{6.2832}}$$

$$R_2 = \sqrt{\frac{a + \frac{a}{2}}{3.1416}}$$

$$R_3 = \sqrt{\frac{2\,a + \frac{a}{2}}{3.1416}}$$

$$R_4 = \sqrt{\frac{3\,a + \frac{a}{2}}{3.1416}}$$

where R_1, R_2, R_3 and R_4 = the distances from the center to the points where the readings should be taken in each successive ring, and a = the area of each zone or ring.

TABLE I. CORRESPONDING VELOCITY FOR DRY AIR AT VARIOUS PRESSURES AND TEMPERATURES

Pressure		Temperature, Deg. F.								
Inches	Ounces	50	60	70	80	100	150	200	300	500
0.1	0.0577	1242	1255	1266	1278	1,300	1,358	1,413	1,516	1,704
0.2	0.1154	1757	1776	1791	1808	1,841	1,921	2,000	2,145	2,411
0.25	0.1443	1965	1986	2003	2022	2,059	2,149	2,235	2,399	2,696
0.3	0.1730	2151	2175	2193	2214	2,254	2,352	2,447	2,626	2,952
0.4	0.2308	2485	2512	2533	2557	2,603	2,717	2,827	3,033	3,409
0.5	0.2884	2778	2808	2832	2859	2,911	3,038	3,160	3,391	3,812
0.6	0.3460	3043	3076	3102	3131	3,188	3,327	3,462	3,715	4,175
0.7	0.4037	3287	3323	3351	3383	3,445	3,595	3,740	4,013	4,510
0.75	0.4326	3402	3439	3468	3501	3,565	3,720	3,870	4,153	4,668
0.8	0.4614	3524	3552	3582	3616	3,682	3,843	3,997	4,290	4,823
0.9	0.5190	3728	3768	3800	3836	3,906	4,076	4,241	4,550	5,114
1.0	0.5768	3929	3971	4005	4043	4,117	4,296	4,470	4,796	5,390
1.25	0.7209	4393	4440	4478	4520	4,602	4,804	4,997	5,362	6,027
1.50	0.8650	4812	4864	4905	4952	5,042	5,262	5,474	5,874	6,602
1.75	1.0092	5197	5254	5298	5348	5,446	5,683	5,912	6,344	7,131
2.00	1.1535	5556	5616	5664	5718	5,822	6,076	6,320	6,783	7,624
2.25	1.2975	5892	5956	6007	6064	6,174	6,443	6,704	7,193	8,085
2.50	1.4418	6211	6278	6332	6392	6,508	6,792	7,066	7,582	8,523
2.75	1.5860	6514	6585	6641	6704	6,827	7,124	7,412	7,952	8,938
3.00	1.7300	6807	6879	6937	7003	7,130	7,440	7,742	8,307	9,336
4.00	2.3070	7857	7942	8010	8086	8,233	8,592	8,940	9,581	10,780
5.00	2.8840	8772	8867	8943	9027	9,192	9,593	9,980	10,710	12,037
6.00	3.4600	9623	9728	9810	9903	10,083	10,523	10,950	11,750	13,203

The location of the points on a traverse where readings should be taken is shown in Fig. 3. While theoretically four readings should be taken in the center zone, as a matter of fact the velocity over this area may be considered practically constant, and no appreciable error will be caused by taking only one reading at the center. The values in Table 2 are based on the above formulas for

TABLE 2 PIPE TRAVERSE FOR PITOT TUBE READINGS, DISTANCE FROM CENTER OF PIPE TO POINT OF READING IN PER CENT OF PIPE DIAMETER

No. of Equal Areas in Traverse	No. of Readings	First R_1	Second R_2	Third R_3	Fourth R_4	Fifth R_5	Sixth R_6	Seventh R_7	Eighth R_8
3	12	20 4	35 3	45 5					
4	16	17 7	30 5	39 4	46 6				
5	20	15 5	27 2	35 3	41 7	47 4			
6	24	14 5	25 0	32 3	38 2	43 3	47 9		
7	28	13 4	23 1	29 9	35 3	40 1	44 3	48 2	
8	32	12 5	21 6	28 0	33 2	37 6	41 5	45.1	48 4

laying out a traverse and will be found very convenient for that purpose. As an example of its use assume that a traverse is to be made of a 24-in. pipe, twelve readings to be taken. One reading will be taken at $0.204 \times 24 = 4.9$ in. from the center of the pipe; one at $0.353 \times 24 = 8.46$ in. from the center; and one at $0.455 \times 24 = 10.92$ in. from the center.

An example of laying out a traverse and finding the average velocity through a round duct is illustrated in Fig. 3, drawn from test results. Twelve readings were

taken, as shown on the diagram, the points being laid out according to Table 2. The velocities were then computed for each point and the average velocity for each area plotted as shown, the points on the lower and upper half of the plot being the same. A curve drawn through these points will indicate the velocity at the edge and at the center of the pipe, and these points should be used in calculating the average velocity.

Circulation through Shunted Hot Water Radiators

By L. L. Brewster

Two common methods of installing the piping and radiators for a hot-water heating system are in common use in this country. In one the risers and return mains, of which there are several in various parts of the building, are run vertically and the connections to the radiating surface are made from the vertical riser and return pipes. In the other, usually a single pair of risers extend to nearly the full height of the building and on each floor a loop of piping is run around the entire floor as a branch from the riser, and connected to the return pipe. In this system the radiation is connected on each loop, as shown in Fig. 1. The loop itself is usually just under the floor, and radiator connections are taken through the floor to the radiators which are in the story above. The flow of water through the loop is from the riser around the loop and into the return, and almost always this pipe is of a uniform size throughout. At first glance it would seem that there would be no circulation of water whatever through the radiators and the riser, and the reason, therefore, is oftentimes obscure to many who do not stop to analyze the action which takes place.

Under average conditions the temperature of the water flowing into the loop is about 180 deg. F., and the temperature drop through the loop is rarely over 10 deg. F., and often as low as 5 deg. F. This, of course, means that a large volume of water is circulated. The pipe sizes should be so proportioned that the velocity of circulation is not over 10 ft., and good practice confines it to about 7 or 8 ft. per sec.

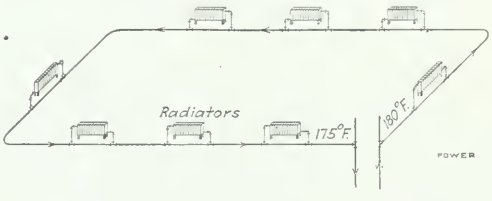


Fig. 1. Shunted Radiators of Hot-water System

The explanation of water circulation through the radiator can best be understood by reference to Fig. 2. In the first place, assume that the radiator is connected to the large tank (shown in dotted lines) of hot water at 180 deg. F., which is not in circulation, but which is maintained at about this temperature. With a room temperature of 70 deg. F. or less, there will be a temperature difference of 110 deg., which is quite sufficient to cool the water in the radiator enough to produce a distinct and positive difference of static head between the riser and return connections. In other words, there is a thermo-siphon action due to the cooling of the water in the radiator which produces a flow in exactly this same way and just as positively as in any hot-water heating system where the circulation is not forced, and also as in a great many cooling arrangements in use in connection with gas or gasoline engines. This circulation will continue just as long as there is a difference in temperature between the water in the radiator and that in the tank below.

If for the tank the pipe which constitutes the loop is substituted, the same action follows, even though the water in the loop may be moving at considerable velocity. The thermo-siphon effect which produces a circulation through each radiator is just as positive when the radiator is connected to the flow main, as if it were connected to a stationary tank or reservoir of water.

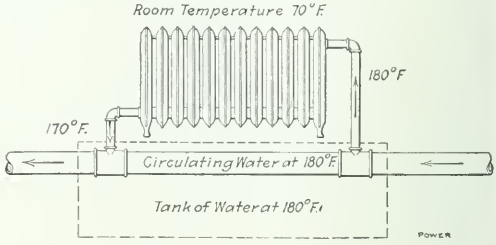


Fig. 2. Illustrating Flow through Radiator

It has been assumed and stated by some that the flow of water through the radiator is due to the fact that the path through the radiator is one of less resistance than that through the main, but this is not so. It matters not what the relative location of the flow main and radiator may be, or what the connections may be, except that one connection to the radiator should be made at a higher elevation than the other. Circulation will take place as long as there is a cooling effect which will decrease the temperature of the water in the radiator below that in the flow main.

In reality, the condition of flow through a single radiator or through any number of radiators considered individually, is brought about in exactly the same manner and is just as positive as the circulation of hot water in any hot-water heating system in which the water is not mechanically driven through the system of piping. The water in the flow main or loop may in this sense be considered a source of heat just as the hot-water heater in the complete system is, and in this case the radiator itself with its connecting piping is a circulating system which operates on the thermo-siphon principle.

[Some discussion of this problem would be of interest. What would happen if the radiator were below the main? Does the difference in head between the two connections to the radiator play no part in the action and what about the relative size of piping? Whether the system operates by gravity or has forced circulation will, of course, make a difference, and in the discussion the type of system should be specified.—Editor.]

A well designed and operated furnace will burn many coals without smoke up to a certain number of pounds per hour, the rate varying with different coals, depending on their chemical composition. If more than this amount is burned, the efficiency will decrease and smoke will be made, owing to the lack of furnace capacity to supply air and mix gases.—"Practical Electricity and Engineering," Nov., '12.

EDITORIALS

Why Do Economizers Explode?

It is not often that an economizer explodes, but when one does the results are as disastrous to life and property as if occasioned by a boiler explosion.

Perhaps it is because so little has been published regarding economizer accidents that engineers have looked upon them as nothing more to be feared than a feed-water heater. Perhaps defects and weaknesses in economizers are considered of so little moment, viewed from the point of safety, that they are looked upon as commonplace, and not worth talking about, but is this true?

What causes an economizer to explode and what precaution should be taken to insure its safety in operation? Apparently there are several reasons why damage to the power plant may occur, some of which are occasioned by carelessness on the part of an attendant. For instance, an economizer may be cut out of service for cleaning or repairs. The gases from the boiler furnaces are bypassed to the chimney, and the feed water is shut off from the economizer. After repairs have been made there is a chance that the hot furnace gases may be turned through the economizer again without opening the valves in the inlet and outlet pipes. The water in the economizer would become heated, steam would be generated and an explosion from excessive pressure would occur.

Another possible cause of explosion is an accumulation of gases in the economizer after it has been cut out of service, due to a leaking damper. A lighted torch could ignite the gas, which might wreck the economizer.

If the economizer were cut out of service for any reason and the dampers leak, what is to prevent the water left in the tubes from generating steam to a pressure sufficient to explode the economizer? How much leakage of hot gases past the dampers would be necessary to produce this result?

Most economizers are so piped that the feed water is pumped from an open heater, through them to the boilers; the economizer would then be under boiler pressure. If a header or tube becomes weakened, the pressure may cause a rupture with serious results.

Suppose the firemen in the boiler room attend to the water level in the boilers they are operating and suppose the demand for steam decreases for a time, each fireman would naturally shut off the supply of feed water to his boilers, not by throttling the pump, but by closing the valve in the feed pipes, paying no attention to what the other firemen were doing. If the pump were not equipped with a regulator the pressure would build up in the economizer, if it is between the pump and the boiler, and most of them are. What happens? The pump continues to operate at its normal capacity, but as the discharge beyond the economizer has been throttled the pressure in the economizer becomes so excessive that the metal is ruptured, and the water at high temperature flashes into steam, producing a terrific explosion.

Such a condition could occur with each fireman working independent of the other. It might not happen in years of service, but if the firemen were not working together there would be such a danger.

Owing to the location and work done by economizers it is difficult to inspect them as thoroughly as a steam boiler, but it is just as necessary. Many interesting experiences with economizers could doubtless be related by engineers who have operated them, which, if published, would be of value in assisting others to prevent accidents from various causes. If any reader has had any such experience, we would welcome its account for publication.

Be Neighborly

The custom among engineers of visiting other plants to look over the equipment and exchange ideas is good and should be encouraged. Some acquaintances thus made from what was intended as a casual visit develop into lasting and mutually helpful friendships. Seldom will a visit to a strange plant be made without some benefit being derived. Unfamiliar machinery is seen in operation and discussed, new and original methods of boiler and engine management are noticed, working conditions and wages may be talked over and comparisons drawn; all of which tend to establish a bond of fraternity in a vocation which is individually isolated.

As a rule, engineer visitors are cordially received and given every opportunity to enjoy and profit by their visits. Occasionally, however, the visitor is not admitted until he has been cross-examined as to his identity and the purpose of his visit in a way he may think uncalled for and resent. Offense at such a greeting should not be taken too quickly, as it is quite likely that the engineer is merely justifiably cautious, and the reserve, or possibly incivility, generally disappears when he is satisfied that the visitor has no ulterior motive.

Itinerent pedlars and, too frequently, agents for engineering supply houses are responsible for this caution on the part of the engineer. Instead of stating their business in a direct, straight-forward manner and leaving it to the engineer as to whether he is interested or can spare the time to discuss the matter, many agents adopt the subterfuge of being desirous of looking the plant over, and when it is believed that the engineer's attention can be compelled, samples are produced and the real object of the visit is disclosed. Naturally the engineer resents this thievery of his time, and consequently is suspicious of visitors and a bit chilly in his attitude toward them.

Another undesirable visitor who has done much to rub the "Welcome" off the power-plant mat is the bibulous engineer who has abundant leisure and intrudes in engine and boiler rooms while in a condition which cannot be tolerated. In the engineering vocation, as in other walks of life, a man is likely to be judged by the personal appearance and demeanor of the people he entertains.

As a class, engineers are broad-minded and affable; so one need not hesitate to ask admittance if he plainly states his purpose and his appearance is respectable.

The American Institute of Steam Boiler Inspectors

As the steam boiler is, and undoubtedly always will be the most vital part of power-plant equipment, any and all organized effort to better plant conditions and promote public safety by encouraging the building of better boilers and the exercise of greater care in their operation and upkeep is to be welcomed.

The American Institute of Steam Boiler Inspectors organized about two years ago is proving a factor for good in this direction. By exchanging ideas and experiences and listening to lectures dealing with every phase of boiler design, construction and operation, the boiler inspector becomes more valuable to society and his employer.

Much ado is made of the avoidable destruction of life and property by the country's industries. That is as it should be. It is strange that so little attention is paid by the general public to the destruction of life and property by the explosion of steam boilers. There is, on an average, one boiler explosion a day, each more or less destructive of life and property, and too often these losses are avoidable.

Besides learning how to do their own work better the work of the boiler inspectors' institute should be to combat this evil by promoting boiler legislation. Surely there are few organizations better qualified to draw up good boiler laws than the inspectors. To do their everyday work at all they must be specialized in finding defects and their causes and in recommending the proper use of defective boilers until the necessary repairs are made.

The institute will be glad to have the coöperation of engineers, boiler makers, designers, etc., and as all of its meetings are open ones, the plant engineer and others, by attending and participating in the discussions, not only can coöperate but can learn much that is valuable to them and which will aid them in performing their own work better. We wish success to the American Institute of Boiler Inspectors.

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The Divine Affirmative

Somewhere sometime we read something about something like that—and it made a deep impression. The gist of it was that the fellow that succeeds is he that asserts himself. When he gives orders, obedience is impulsive; there is no doubtful tone to the command and it is a foregone conclusion that what is asked simply must be done. Those receiving the instructions find themselves carrying them out before they have had time to raise any questions as to whether or not they can or should carry them out.

Perhaps this chap with the confident manner has no more—maybe less—ability than the timid, diffident apologetic man, but he gets higher up in the scale of life's successes by sheer force of his pugnacity.

The worst thing about this "divine affirmative" is its close relationship to a quality that is anything but divine, and hasn't such a polite name either—just plain "bluff."

How often we have heard someone referred to as a "bluff." He knows nothing, but he "chucks a bluff." Very often he "gets away with it." Far be it from us to commend this sort, on general principles, but we must give him credit for having discovered, consciously or unconsciously, the value of self-assertion. He may undeservedly succeed, if not permanently, for a time at least; and it is better to be a "has been" than a "never was." On the other hand, many a one with real merit never has attained the success he deserves and nine hundred and ninety-nine times out of a thousand, the explanation is the same, although variously characterized as "lack of push," "diffidence," "modesty," "inertia," "lack of self-confidence," etc. But it makes no difference what it is called; they are all one and the same thing.

These two types of men are prevalent and account for such apparent inconsistencies as the fool of his class now riding in his automobile while the honor man barely ekes out an existence. That the one succeeds, often in spite of lack of ability, and that the other fails, usually in spite of ability, is only a matter of psychology after all. It is instinct to trust, without question, the self-reliant man, to grant authority to him who assumes it and generally to make way for the forceful, masterful man. Equally is it natural to distrust without reason the hesitant man, to ignore the behests of him who cannot appropriate authority and make it a practice of pushing aside the man who offers no resistance.

Take pattern from the bluff, but beat him at his own game by being prepared to make good when tested, for, although the world stands aside while the "pusher" goes by, it examines him carefully from the rear and if he presumed without "having the goods" it trips him up before he gets far.

⁂

The Central Station

If the running of many small industries from a central power plant is the social-economical thing to do it will be done and no blind opposition or senseless wriggling under the squeezing process will stop it.

But is it? If an individual owned any large city and everything in it, would he put in a single large power station and run everything from it, or would he have a multiplicity of small plants, one for each industry? Probably he would do neither. He would group neighborhood plants so as to get the economy of aggregation and the averaging effect of multiple demand, and to use the heat rejected by the engines for heating and other useful purposes.

There are many places where central-station current is logical, economical and the right thing to use. There are many places where it is a misfit and where it costs the customer much more than he could make it for, and very much more than he and his neighbors upon the same block could make it for, if they would put a power plant in one of the courts or cellars of the block and heat, light and drive the whole block from it, each tenant or user paying his proportionate share.

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One of the simplest pieces of apparatus used in the testing of power-plant equipment is also one of the least used—the pitot tube. Frank L. Busey has likely hit the true explanation of this in his account of its use in air measurements on page 156, where he says: "That it is not more extensively used is probably due to the fact that it is not more generally understood." He then proceeds to try to overcome this obstacle by explaining the instrument in very clear and simple language and indicates its wide field of usefulness.

READERS WITH SOMETHING TO SAY

Division of Expense in Isolated Plant

I have read with considerable interest different articles in POWER and other mechanical papers on the victories won by the isolated plant and also on the operation of such plants, but very few articles are accompanied with figures showing the division of expenses of all-year operation, showing what should be charged to the heating system if there were no engines and generators, and charging to the electrical output during the summer months everything except what would be needed to keep the place in operation if there was no plant.

I hope to see more on the subject and trust that the authors will give the data mentioned above.

C. WHITE.

St. Louis, Mo.

Examination Questions

The following questions were asked an applicant for a first-class engineer's license in Massachusetts:

1. How would you put the spool in the center of the rod of a duplex pump (it having slipped) if there were no marks to guide you?

2. How would you get a piston off a duplex pump if you had tried a lead hammer on the end of the rod and it had proved unsuccessful?

3. How many steam ports are there in a duplex pump? Why?

4. What are compression valves for on a duplex pump?

5. Did you ever put a new set of snap rings in a solid piston of an engine?

6. What did you have to do to them before putting them in?

7. What diameter snap rings would you order for a 12-in. piston?

8. Supposing the rings were just cut across, how would you know, without figuring, just exactly how much to take out in one cut to bring a ring to the required size?

9. Did you ever take the piston out of an American Ball engine? What did you have to be very careful of when taking the piston out?

10. How did you put it back? How did you get it by the counterbore?

11. Did you ever have the valve of the American Ball engine out? What did it look like? How did you put it back again?

12. What peculiarity has the Ames engine? How would you change the lead without changing any of the moving parts or changing the position of the wheel and still have the lead equal on each end?

13. If you just took charge of a plant and you had a high-speed engine, how would you find out how much clearance you had on each end, there being no marks for striking points and no time to find them, and you had to start up in a few minutes?

14. Were you ever inside a B. & W. boiler? Where and how does the feed water come in? Where is the mud drum?

15. Show by a drawing how the tubes of a B. & W. boiler are placed with reference to the steam and water drum? Show where the baffles are placed in this boiler and the path taken by the gases.

16. Give two reasons for the tubes being inclined.

17. How are the tubes placed with reference to the drum of a Heine boiler? How much higher is the water in the rear end of a Heine boiler than in the front, the boiler being 18 ft. long?

18. What does the feed pipe of a B. & W. boiler pass through on the inside of the drum? How is it supported?

19. Where is the mud drum in a Heine boiler?

20. How would you get up to put a new fusible plug in a B. & W. boiler?

21. How would you get to the other side of the baffle-plate above the tubes?

22. What would you be very careful of in putting a new tube in the bottom row of a B. & W. boiler? How would you get the old one out? What kind of a cutter is used?

23. If you put a welded tube in, where would you put the weld?

24. What would you be particularly careful of in regard to the ends of the tubes?

25. How are the short nipples connecting the mud drum of a B. & W. boiler made tight? What does the tool look like that is used in the process?

26. If a man came from the boiler shop and expanded some new nipples in the mud drum of a B. & W. boiler, how would you know if the job would be tight before you started the boiler?

27. How is the B. & W. boiler supported?

28. How would you clean the soot from the back of the bridge-wall?

29. What care would you give the mud drum of a B. & W. boiler?

30. How is the Heine boiler supported?

31. Show by a sketch how the baffle-plates are placed in a Heine boiler and also show the travel of the gases.

32. How do the Heine stay-bolts differ from ordinary stay-bolts? Why are they hollow?

33. How are the plates put in a Heine boiler? Where are the handholes?

34. How would you clean out the mud drum of a Heine boiler if the blowoff to the mud drum got plugged up?

35. (Showing a safety valve in which the valve is not attached to the spindle.) Is this a Massachusetts standard valve? Why? If this valve had a blow-down ring, where would it be? If you wanted this valve to blow at 50 lb. higher pressure, what would you do?

36. Explain the advantages of superheated steam.

37. Does the Stirling boiler have straight tubes?

38. Show by drawing how the steam and water drums are connected in the Stirling boiler.

39. Show the path of the water circulation in this boiler.

40. What is a cross-box? How is it made? How is it attached to a boiler?

41. What shape are the holes cut in the drums of boilers having cross-boxes? Doesn't this weaken the boiler?

42. Why is it the Heine boiler has throat braces near this point, while the B. & W. has not?

43. Show how the Stirling boiler is supported.

44. How would you clean out the bottom drum?

45. Where does the feed water enter in the Stirling boiler?

46. Did you ever run the Rollins engine?

47. How do you equalize the cutoff on the Rollins engine?

48. How do you equalize the cutoff on the Putnam engine?

49. What is there on a Brown engine to equalize the cutoff? Does the Brown engine ever have a different method of adjustment? If so, describe it.

50. Of what material is the shell of a return-tubular boiler made? What material is used in the heads? What is the limit of the tensile strength for each?

51. Suppose you fitted a new snap ring to a piston of an engine, and the ring proved to be too narrow for the recess, and every time the engine took steam on that end, the incoming steam caused the loose ring to knock. What would you do to stop it without getting a new ring?

52. Did you ever run a condensing engine?

53. What kind of a condenser did it have?

54. With a jet condenser, how would you start the engine?

55. If you were called away from the engine room for twenty-five minutes and while you were gone a considerable load was thrown on the engine, how would you find things when you got back?

56. If you were carrying 28 in. of vacuum and lost it, how much would you have to increase the boiler pressure to carry the same load and cutoff at one-quarter stroke, the same as before losing the vacuum?

57. Is there any danger of getting water in the engine with a jet condenser? What do they do to prevent it? Do all jet condensers have vacuum breakers?

58. Is there any danger of water getting into the cylinder with a surface condenser? If so, why?

59. Is there any danger of water getting into the cylinder, with a siphon condenser?

60. Why does a siphon condenser require a tail pipe? How long is the tail pipe?

61. Do you require to pump the condensing water to a siphon condenser?

62. Did you ever run a siphon condenser?

63. If there were a small air leak about half way up the tail pipe, how would it affect the vacuum?

64. How many bolt holes are there in a 12-in. standard flange?

65. Can you change the cutoff of one steam valve of the Putnam engine, without changing the cutoff of both?

OLSEN M. JACKSON.

South Weymouth, Mass.

Notes on Portable Steam Engines

Portable self-contained steam units consisting of a locomotive-type boiler with an engine mounted on the barrel of the boiler, and the whole mounted upon wheels, are largely used for agricultural and construction purposes Such a method of construction is common both to the large traction engine for road haulage and the steam road roller. There are one or two unusual features concerning such steam units worthy of notice. The first is the special precautions necessary in setting the slide valves. It is obvious that such an engine having a hot boiler shell as a bed, requires rather different treatment to that accorded to the valves of an ordinary horizontal engine. If the valves are set carefully in the ordinary way, the efficiency of the plant and its consequent economy are seriously impaired. Many instances are known where an otherwise capable engineer has failed to take the boiler expansion into account and then has been sorely puzzled at the alarming increase in coal consumption after overhauling the engine.

There is, of course, only one way to do the job, and that is after thorough overhauling and elimination of slack due to wear, to leave the slide-chest covers off, and raise steam in the boiler. As much as 1/8 in. is quite an ordinary extension in length of the portion of the shell serving as the engine bed. This error in setting small valves makes a considerable difference in the results. The expansion also alters piston clearances. Total clearance should be allowed at the front or the crank end of the cylinder if adjustment is made cold. The expansion of the boiler then provides 1/8-in. clearance under cover.

Usually the trouble is caused by the ordinary conditions of overhauling. The responsible mechanic, who it must be remembered has nothing to do with the engine under steam, having opened up the cylinder, assumes the valves are improperly set and follows the usual practice of centering the cranks and splitting valve lead at each end of the stroke.

When the steam is on the boiler, as already detailed, the setting becomes so faulty that the engine is troublesome to handle, lead being doubled at one end of the stroke and "blind" at the other. Another disadvantage results from the juxtaposition of hot boiler shell and engine. The bearings are always warm. This fact makes the provision of a good lubricating oil of high viscosity imperative, ordinary engine lubricating oil being too light.

A. L. HAAS.

London, England.

Diagrams of Cross Compound Engine Wanted

The writer is desirous of studying conditions of valve adjustment for best results in running a Corliss cross-compound condensing engine and would be glad to receive diagrams from some brother engineer taken from such an engine, driving full load, when running condensing and when running noncondensing, with valves set for only enough compression for quiet running when running condensing. The main object is to note the difference in compression when running the engine under the conditions stated.

L. G. BORDEN.

Wharton, Tex.

QUESTIONS BEFORE THE HOUSE

The Value of the Horsepower

Referring to my article on horsepower, Jan 28 issue, I find that the conversion table on page 71 of Marks & Davis' "Steam Tables and Diagrams" gives

1 hp. = 550* ft.-lb. per sec.
1 hp. = 0.7457 kw.
1 cheval-vapeur, or Pferdekraft, or "continental horsepower" is 75-kg.-meters per sec.
1 hp. = 1.0139 chev.-vap. = 0.7604 poncelet.
1 poncelet = 100 kg.-meters per sec.
1 ft.-lb. = 3.7662×10^{4} watt-hours = 32.174 ft.-poundals.

These figures correspond exactly to the ones I gave. Marks & Davis' tables are generally accepted as standard by American engineers. The horsepower thus represents "the same amount of power at different places," and its relation to the watt is a definite number (see Circular No. 34, page 11)

$$1\ hp. = 745.7\ watts$$

WILLIAM KENT.

New York City.

Cooling Pond of Crescent Plant

The test report of the performance of the power plant at Wampum, Penn., with reference to the impounded reservoir for condensing purposes, in the issue of Dec. 3 was read with interest. It was my pleasure to visit this plant while it was in operation on several occasions during the last two years. I have come to the conclusion that it is the worst arrangement for a hot-water cooler that I have ever seen. This reservoir is certainly large enough (about 6½ acres), the trouble is that there is practically no movement to the water, the surface being as placid as a plate of glass. The condensate flows into this reservoir at one end and is drawn out near the other end with a total fall of about one foot, and as the weather becomes warm in the early summer the entire volume warms up and remains hot until the cold weather comes on again.

I most certainly disagree with the engineers who designed this plant that the reservoir will cool the water of condensation sufficiently. My observation leads me to the conclusion that it is practically impossible to provide a reservoir of this design of sufficient capacity to maintain a low temperature during the entire summer.

A casual glance over the report submitted tells the story. This is a modern power plant and yet the injection water is so hot that the best vacuum possible is 22 in. with the barometer at 30 in. and the barometer stands like this for nearly four months of the year. A well designed spray system must be added to distribute the hot water to produce a modern economical condensing plant.

As most of us know, a portland-cement mill is kept in operation day and night for usually about ten months in the year, being only shut down during severely cold weather, just when this reservoir would be most effective. But with the addition of a properly designed cooling system, it would be very successful in keeping the water cool during the summer season when the mill is run continuously night and day.

CHARLES W. WILSON.

New Castle, Penn.

*Exact value by definition.

Dalton's Law in the Steam Plant

In the article under the above title, appearing in the issue of Dec. 31, the author discusses the flash point of an oil, as an illustration of the application of Dalton's law. He endeavors to show the error in the common idea that the flash point will be made higher by heating the oil in an atmosphere of steam or air under 150 lb. pressure, and states, "Now the flash point, or the temperature at which ignitable vapors are given off, of most steam-engine cylinder oils is usually between 500 and 600 deg. F. They evidently then have to be heated to this temperature before their vapor pressure equals that of atmosphere, so that at 366 deg. F. (temperature corresponding to 150 lb. steam pressure) their vapor pressure must be quite low and the 150 lb. steam (a different gas) pressure can have no deterent effect on the formation of the oil vapor. If the oil were tested in a closed room where the air pressure is 150 lb., the same flash point would result."

The above statement is inaccurate and quite misleading, and as the question of the flashing of an oil is commercially important, though often misunderstood, it is worth while to find in just what way Dalton's law becomes applicable to a case of this kind, where an explosive mixture is formed.

Consider first the simple case of an open pot containing a liquid, with atmospheric air above. Whatever the liquid there is always some tendency toward vaporization, and there is always, therefore, some vapor present and mixed with the air above the liquid. Not only that, but there is a quantitative relation between the weight of air and weight of vapor present. As was rightly pointed out in the article referred to, vaporization occurs until a certain known maximum vapor pressure is reached, which is dependent solely on the temperature. Now, since the total pressure of the vapor-air mixture is the barometric pressure, and since both vapor and air fill the volume and exert their own pressure, it is not difficult to show that the following relation holds true:

$$\frac{Weight\ of\ vapor}{Weight\ of\ air} = \frac{pressure\ of\ vapor}{pressure\ of\ air} \times \frac{density\ of\ vapor}{density\ of\ air}$$

in which both densities are taken at atmospheric pressure. In the above equation the pressure of the air will be the barometric pressure minus the vapor pressure.

This quantitative relation must be kept strongly in mind, because it shows that for every pound of air above a liquid at a given temperature there is a definite frac-

tion of a pound of vapor mixed with it. If the total pressure were anything other than barometric, the same relation would hold, except that the air pressure would now be total pressure minus vapor pressure.

It is obvious that if the air above a liquid is kept in continuous circulation, vaporization will go on continuously so as to always maintain the proper proportion. From experience it is known that this does occur provided the heat necessary for vaporization can be supplied to keep the temperature from falling. Assume an oil in an open pot being heated slowly by a flame applied underneath, so that the temperature changes are gradual. Vaporization occurs at each temperature until the gas mixture above the oil is composed of air and oil vapor in the proportions determined by the equation given previously. If early in the test a lighted taper be applied above the pot, ignition will not occur, because the ratio of oil vapor to air does not represent an explosive mixture; in other words, the mixture is too lean to take fire, even though the taper is at a temperature higher than that at which ignition would occur.

As the temperature of the oil is increased, however, its vapor pressure becomes greater and as may be readily seen from the equation the gas mixture becomes richer until explosive proportions are reached, and the oil will flash. Flashing simply is the instantaneous bursting into flame and extinction of the gas mixture above the oil. The reason that the entire mass does not burn is that vaporization must always precede burning, and that by the time the liquid just below the ignited vapor has received heat enough to vaporize and form igniting proportions, the temperature is too low for ignition.

If more heat is applied below the pot and the temperature increased still further, there will be igniting proportions continuously, but it may be necessary to go 30 or 40 deg. further before reaching the burning point. At this point the liquid receives heat enough from the ignition to vaporize and form igniting proportions before the temperature has dropped below the ignition point, and the whole mass bursts into flame.

Finally, consider the case of the oil under a pressure of 150 lb. If this is steam pressure and there is no air present, the oil can never flash whatever the temperature, because there is no air to burn it. However, the vaporization will occur in accordance with the equation given. On the other hand, if it is air pressure, and say that the flash-point test is being made in a room where the air pressure is 150 lb., then the flash temperature will be materially changed, due to the high pressure.

At any temperature the proportion will apply that

$$\frac{\text{Weight of vapor}}{\text{Weight of air}} = \frac{\text{vapor pressure}}{150 \text{ lb.} - \text{vapor pressure}} \times \frac{\text{density of vapor}}{\text{density of air}}$$

It needs little consideration to see that at a given temperature the gas mixture above the pot will be much leaner with the total pressure 150 lb. than with the total pressure barometric. In other words, the vapor pressure is now a much smaller fraction of the total pressure, so that the weight of vapor is a much smaller fraction of air. Consequently, the temperature will have to be considerably increased before explosive proportions are reached, which means that the flash point is considerably higher.

New York City. LOUIS GROSSBAUM.

The Logical Unit of Power

The editorial under the above caption in POWER of Dec. 3, 1912, led me to secure circular No. 34, of the Bureau of Standards, on "relation of horsepower to kilowatt."

It may be of interest to look into the accuracy of the kilowatt a little. In the table given by the Bureau of Standards, the lowest equivalent is 745.6 watts, the highest 746 watts, a variation of four parts in 7460, or one part in 1865. It is improbable that the ampere is known within one part in 10,000, although the recent work of Smith and Mather may have determined it more closely. The true ohm is probably not known within three parts in 7500, or one in 2500; the present international ohm is reproducible within about one part in 50,000, but there is little work done with an accuracy of over five parts in 7500. The volt, of course, is known only within the combined accuracy of the ohm and ampere determinations already made. What is the accuracy of the ordinary electrical measuring apparatus in commercial use? Probably one part in 1000.

What then is the effect upon the operating engineer of Circular 34? Apparently only to give him the momentous information that the Bureau of Standards will hereafter do what he has already been doing, divide kilowatts by 0.746 to get horsepower.

Is the statement in the editorial correct, that the kilowatt is based on physical phenomena which have the same value at all points within man's reach? I was under the impression that in the ultimate analysis, the ampere had to be determined by the ampere balance, which depends upon gravity, and the determination of g, for its accuracy.

DONALD M. LIDDELL.

Elizabeth, N. J.

Condensers for Lubricator

Relative to the repair to a lubricator condenser, as described in the Jan. 7 issue, I submit the following:

The main object of a lubricator condenser is to insure a more constant level, or head, of water working on the lubricator. The lubricator depends upon this water head for its operation. Therefore, it is apparent, that to obtain a constant flow of oil, the water level must be maintained constant. The same amount of water could be stored in a straight pipe, if it were long enough, as can be stored in the bulb-form condenser, but when the demand for oil is greater than normal, the head of water, which is causing the flow of oil, is considerably altered. This results in a decreased flow of oil unless the setting of the needle valve governing the feed oil is changed. Should this valve setting be altered, the flow will gradually increase as the water rises again in the pipe, for when the water falls the condensing surface increases and consequently a greater supply of water follows.

To guard against this continual fluctuation, the condenser has been added, which, because of its greater horizontal cross-section, allows of a certain demand for water, with a very slight variation in head.

Fort Flagler, Wash. J. M. ROW.

INQUIRIES OF GENERAL INTEREST

Zinc in the Return Tank—Will zinc placed in the return tank keep the boiler from pitting just as well as when placed in the boiler?

I. M

Zinc in the return tank would have no appreciable effect.

Position of Blow-off Valve and Cock—When a valve and cock are used on a boiler, which should be placed next the boiler? Which should be opened first when the boiler is blown off.

G. B. L.

The cock should be placed next to the boiler. In blowing off the boiler, the valve should be opened first, thus preventing the whole pressure from coming on the valve.

Water Required to Condense 40,000 lb. of Steam Per Hour—When using a surface condenser, how much water will be required to condense 40,000 lb. of steam per hour?

G. S.

Where the condenser is clean and tight, 600,000 lb. per hour will be sufficient. As, under ordinary operating conditions, the condenser and the piping will not remain clean and tight, provision should be made for at least 800,000 lb., or 96,000 gal., of water per hour at a temperature of 70 deg. F.

Relation of Piston Displacement to Volume of Water—What relation should the piston displacement of a pump bear to the volume of water which is to be pumped for a jet condenser at full load?

P. J. F.

Surface water under atmospheric pressure ordinarily contains 2 to 12 per cent. of air by volume. To provide for the presence of air, the leakage of air and other causes of pump slippage, a very liberal factor is usually allowed, an average figure being about 20 per cent. excess capacity.

Preventing Rust from Salt Water—What is the best way to keep pipes and iron work from rusting when exposed to the action of salt water?

F. J. R.

The best method is to thoroughly clean the iron work, paint it with red lead and then give the work a coat of hot asphalt paint. Steel pipe and iron work which are made from impure material are most inclined to rust in the presence of salt water, the oxidation being likely to break through almost any kind of coating. Usually, this may be prevented by giving the material a coating of something which will exclude the moisture of the atmosphere as much as possible.

To Determine Boiler Water Evaporation—How is the amount of water evaporated by a boiler determined?

M. C.

The amount is best found by weighing the feed water for a period of at least 10 hr. A shorter test may be made, but it would not be so accurate. Dividing the number of pounds of water by the number of hours would give the amount of water evaporated per hour. In making such a test care should be taken that all of the water fed is weighed and that all of the water credited to the boiler be fed to the boiler and evaporated into steam. All leaks from blowoff valves, etc., should be stopped before the test or accurately accounted for.

Preventing Oil Running on Shaft—How can oil be stopped from running along a shaft from a bearing or other point where it is in contact with the shaft?

C. H. W.

Mount a sharp-edged disk on the shaft that the oil may be driven off the disk by centrifugal force. It is customary under such circumstances to surround the disk with a shield for catching and draining off the oil. Another method is to use a wiper wick of fibrous material; it will rub on the shaft and wipe off the oil. Such a wiper has to be occasionally renewed and kept clean to prevent the rubbing surface of the wiper from becoming saturated with oil.

Fluctuating Gages—In a 15-ton refrigerating plant, why should the gages registering the suction and condenser pressures fluctuate continually and the suction gage sometimes stick?

W. B.

If there is no valve in the pipe connections to the gages, the hands are sure to fluctuate due to the variation in pressure during suction and discharge. The usual practice is to have a valve in the line connecting the gages, so that they may be throttled down to a point where the fluctuation is not greater than 2 lb. The operator must be careful, of course, not to close the valve entirely, although this would be at once indicated by the pointer dropping back to zero. The sticking of the gage is due to some mechanical defect which a careful inspection should reveal.

Radius Curve of Reverse Link—To what radius should the reverse link of a double eccentric reversible D-slide valve engine be curved, that is, to what part of the engine should this curve be proportioned?

W. A. M.

When the rocker arm has no backset, the correct radius of a link should be equal to the distance on a horizontal line from the center of the main shaft to the center of the rocker box. If the rocker has any backset, subtract the amount of backset from this length. Some locomotive manufacturers make the link radius ¾ in. per ft. less than the above, but the distance given is the correct one and has been so accepted by the Railroad Master Mechanics Association.

Collapsing Strength of Iron Flues and Cylinders—What will be the collapsing strength of a cylindrical iron tank 50 ft. long and 50 in. in diameter made of ¼-in. iron?

J. W. D.

Fairbairn's formula for the collapsing strength of iron cylinders is

$$p = 9{,}675{,}600\,\frac{t^2}{ld}$$

in which

p = Pressure in pounds.
t = Thickness in inches,
l = Length of cylinder in inches,
d = Diameter of cylinder in inches.

Substituting the values given

$$p = \frac{9{,}675{,}600 \times (0.25 \times 0.25)}{(50 \times 12) \times 50} = 20.1575 \text{ lb.}$$

Cost of Water Heating with Live Steam—What would it cost to heat 25,000,000 gal. of water from 55 deg. to an average temperature of 185 deg. F. with live steam at 75-lb. pressure, coal costing $4.40 per long ton, 1 lb. to evaporate 11 lb. of water?

W. J. W.

With an initial temperature of 55 deg., to heat a pound of water to 185 deg. will require

$$185 - 55 = 130 \text{ B.t.u.}$$

As a gallon of water weighs 8¼ lb.,

$$8.33 \times 25{,}000{,}000 = 208{,}250{,}000 \text{ lb.}$$

will be the total weight of water. As each pound requires 130 B.t.u.,

$$208{,}250{,}000 \times 130 \quad 27{,}072{,}500{,}000 \text{ Bt.u.}$$

will be necessary to heat the water. The heat in a pound of steam at 75-lb. gage pressure, above 32 deg. F., is 1184.4 B.t.u. Assuming that steam is discharging from the heating coil at 185 deg., there will be available to heat the water in each pound of steam

$$1184.4 - 153 = 1031.4 \text{ B.t.u.}$$

Then

$$27{,}072{,}500{,}000 \div 1031.4 = 26{,}248{,}303 \text{ lb.}$$

of steam will be required in all. As the evaporation is 11 lb. of water per pound of coal,

$$26{,}248{,}303 \div 11 = 2{,}386{,}209 \text{ lb.}$$

of coal will be needed, or

$$2{,}386{,}209 \div 2240 = 1065.27 \text{ long tons}$$

of coal, which, at $4.40 per ton, will cost

$$1065.27 \times 4.40 = \$4687.19.$$

Some heat will be lost in transmission and from radiation, so that more steam will be needed, making the total cost close to $5000.

ENGINEERS' STUDY COURSE

Formulas

The average rule, when expressed in words, is lengthy and, worst of all, hard to remember. Therefore, the *formula* is used to express mathematical relations and operations. As a formula is an algebraical expression of a rule, letters and symbols are used instead of words.

Take the rule for finding the indicated horsepower of an engine:

Find the continued product of the mean effective pressure in pounds per square inch, the length of stroke in feet, the area of the piston in square inches, and the number of strokes per minute; divide the product by 33,000.

As many know, this rule can be expressed as

$$Hp. = \frac{P \times L \times A \times N}{33{,}000}$$

Where

Hp = Horsepower;
P = Mean effective pressure;
L = Length of stroke in feet;
A = Area of piston in square inches;
N = Number of strokes per minute.

As multiplication signs are not necessary between letters in formulas, this horsepower formula may be shortened:

$$Hp. = \frac{PLAN}{33{,}000}$$

To indicate that quantities are to be multiplied we omit the multiplication sign and set close together the letters which represent these quantities.

Signs of Aggregation or Grouping

In formulas we use nearly all of the same signs that are used in arithmetic. The signs of *aggregation* are most important, as they guide us in the successive steps to be taken in performing calculations.

The signs are: the *parenthesis* ( ), *brackets* [ ], *vinculum* $\overline{\quad}$ and *brace* { }. If we wish to indicate the square root of $786 \div 3$ we would express it thus:

$$\sqrt{786 \div 3} \text{ or } \sqrt{\frac{786}{3}}$$

The old radical sign was $\sqrt{\ }$, but now this sign and the vinculum combined make the radical sign. The parenthesis is the sign most used when only one sign of aggregation is required, although the vinculum may be used for the same purpose.

When only two signs of aggregation are required the parenthesis and brackets are used.

Example: $[(40 - 20) \div 5] \times 20 = 80$

Here the difference between 40 and 20 is to be divided by 5 and the quotient multiplied by 20.

When three signs are required the parenthesis, brackets and brace are used.

Example: $\{[(40 - 20) \div 5] \times 20\} - 4 = 76$

Here the difference between 40 and 20 is to be divided by 5, the quotient multiplied by 20 and 4 subtracted from the product.

Where an example calls for all four signs, the vinculum is used so that a parenthesis will not have to be inclosed within a parenthesis.

Example: $\{[(40 - 20 \div 2) \times 6 - 15] \div 4\} \times 20 = 225$.

Notice that the difference between 40 and 20 is to be divided by 2. The rest of the example is easily understood. All these signs of aggregation are frequently used in formulas and the student should familiarize himself with them.

As letters are used in formulas to designate quantities, it is customary to use the first letter of a quantity to identify it. Thus, in the horsepower formula we have *pressure, length, area* and *number* of strokes per minute, and these quantities are designated P, L, A, N respectively. We usually use V for volume, P for pressure, h for height, g for gravity or the constant acceleration due to the attraction of the earth, etc. This manner of designating quantities is not always done, however, so it is usually best to state below the formula what each letter represents.

In formulas where we have different pressures and volumes to deal with, we cannot use the same kind of letter for all the different pressures, volumes or whatever it is we are dealing with. To distinguish each of the different values of the same quantity we use what is called *primes* and *subs*.

A prime is a mark like a comma, and is placed above and to the right of a letter, thus P', p' or V', v'. The capital letters, P and V in this case, are read P' *major prime*, V' *major prime;* the small letters are read p' *prime* and v' *prime*. Thus we can easily designate, say, boiler pressure, initial pressure and terminal pressure by calling P the boiler pressure, p the initial pressure and p' (p' prime) the terminal pressure. This same manner of designation is applicable for all letters and quantities.

Subs are small numbers placed at the right and below the letters, thus, P_1, p_1 or V_1, v_1. They are read P *major* "sub 1," etc.

If the sub is 2 or 3, etc., the letter is read "sub one" or "sub two," etc. Arabic numbers (1, 2, 3, etc.) should never be used for primes, as the numbers are likely to be taken for exponents.

The student must learn to distinguish between a coefficient and an exponent, thus in the expression $3(bc)^2$. Here 3 is the *coefficient* and 2 is the exponent. Notice that *the coefficient denotes how many times a quantity is taken. The exponent indicates to what power the quantity is to be raised.* Thus in the above expression, the square of the product $b \times c$ is to be multiplied by 3.

In formulas we deal with *equations* and an equation is simply a statement that two expressions have the same value, i.e., they are equal to each other. Thus in the horsepower formula

$$Hp. = \frac{PLAN}{33{,}000}$$

notice that all to the left of the equality sign is of the same value as all to the right, i.e., the continued product of P, L, A and N divided by 33,000 is equal to the horsepower.

Suppose we apply this formula to an 18x42-in. engine running at 80 r.p.m. with 60-lb. m.e.p.

$$Hp. = \frac{PLAN}{33{,}000} = 259.64$$

The student should work out the above example.

We can make a number of equations out of this formula. When we do this we *solve* the formula for each of the values (letters) in terms of the others. Letting the formula apply to the same engine as in the above example, we will solve it for each letter in terms of the others.

$$P = \frac{33{,}000\,Hp.}{LAN} = 60\ lb. = m.e.p.$$

$$A = \frac{33{,}000\,Hp.}{PLN} = 255\ sq.in. = area\ of\ piston$$

$$L = \frac{33{,}000\,Hp.}{PAN} = 3.5\ ft. = length\ of\ stroke$$

$$N = \frac{33{,}000\,Hp.}{PLA} = 160 = number\ of\ strokes = 80\ r.p.m.$$

You will notice that when numerical values are substituted for the letters, the multiplication sign is used.

The segment of a circle is a part of the circle separated from the other part by a straight line.

The formula for finding the area of the segment of a circle when the segment is equal to or less than a semicircle is

$$A = \frac{4\,h^2}{3}\sqrt{\frac{D}{h} - 0.608}$$

in which

D = Diameter of the circle;

h = Height of segment, i.e., the greatest perpendicular distance between the circumference and and the chord or straight line;

0.608 = Constant.

Example: Find the area of the segment of a circle 75 in. in diameter, height of segment 25 in.

Substituting numerical values for the letters we have

$$A = \frac{4 \times 25^2}{3} \times \sqrt{\frac{75}{25} - 0.608} =$$

$$\frac{2500}{3} \times \sqrt{3 - 0.608} = \frac{2500}{3} \times \sqrt{2.392} =$$

$$833.3 \times 1.546 = 1288.43\ sq.in.$$

as the area.

As an example of formula where subs are used the following is given:

To calculate the amount of water required for a surface condenser the formula below is used.

$$W = \frac{H - t_1 + 32}{t_2 - t_3}$$

in which

H = Total heat of 1 lb. exhaust steam above 32 deg. F.;

t_1 = Temperature of condensate;

t_2 = Temperature of discharge water;

t_3 = Temperature of circulating water;

W = Pounds of circulating water required to condense 1 lb. of steam.

Example: How many pounds of circulating water are necessary to condense one pound of steam if the inlet water temperature is 60 deg. F., outlet 90 deg. F., hotwell temperature 101 deg. vacuum to be 28 in.? Here

$H = 1104.1$ B.t.u. (found from the steam tables);

$t_1 = 101$ deg. F.;

$t_2 = 90$ deg. F.;

$t_3 = 60$ deg. F.

Substituting, we have

$$W = \frac{1104 - 101 + 32}{90 - 60} = 34.5\ lb.$$

This shows a ratio of 34.5 lb. water to 1 lb. of steam.

The Massachusetts formula for area of safety valves is

$$A = \frac{W \times 70 \times 11}{P}$$

A = Area of valve in square inches for each square foot of grate surface;

W = Pounds of water evaporated per second per square foot of grate surface;

P = Absolute pressure per square inch at which valve is to open or blow.

Example: With a grate area of 30 sq.ft. and a combustion rate of 20 lb. of coal per sq.ft. of grate surface per hour, an evaporation of 10 lb. of water per pound of coal and with 100-lb. gage pressure, what size safety valve is required?

$$30 \times 20 = 600\ lb.$$

coal burned per hour.

$$600 \times 10 = 6000\ lb.$$

water evaporated per hour.

$$\frac{6000}{3600} = 1.67\ lb.$$

water evaporated per second.

$$1.67 \div 30 = 0.0556\ lb.$$

water evaporated per square foot grate per second.

Applying the formula

$$A = \frac{0.0556 \times 70 \times 11}{115} = 3.728\ sq.in.$$

The commercial size valve would be 2½ in.

A symbol frequently used in formulas is π, which is a Greek letter pronounced "Pi." The value of π is 3.1416, which is the ratio of the circumference to the diameter of a circle. Thus we have for the circle

$$C = D\pi$$

$$D = \frac{C}{\pi}$$

where

C = Circumference;

D = Diameter.

The Royal Society of Edinburgh is forming a provisional committee to consider how the tercentenary of the discovery of logarithms may best be celebrated. The year for this celebration will be 1914, as it was in 1614 that John Napier's "De Mirifici Logarithmorum Canonis Descriptio" appeared, although, according to Kepler, Napier had indicated his acquaintance with the properties of logarithms as early as 1594, in a letter to Tycho Brahe. Napier's logarithms were, of course, based on the sum of the series

$$1 + \frac{1}{1} + \frac{1}{1.2} + \frac{1}{1.2.3} + \cdots \frac{1}{1.2.3 \ldots \infty}$$

approximately equal to 2.718281828. It was not until 1624 that Briggs published his "Arithmetica Logarithmica," using the base 10. The appearance of Napier's "De Descriptio," supplemented by his posthumous, "De Mirifici Canonis Constructio" (1617), may be considered as an event but little less important than Newton's "Principia." John Napier was born in Merchiston, near Edinburgh, in 1550, and died there Apr. 4, 1617.—"Engineering and Mining Journal."

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Thomas A. Edison is too busy inventing to waste his time having medals pinned on him, so Mrs. Edison accepted the Rathenau medal from the Museum of Safety. This sounds like real modesty.

Mr. Andrew Carnegie was also present—and spoke. The daily press relates a story that Mr. Carnegie did not seem to recognize the building. "Why this," said Mr. Williams, "is your own building, built by you for the benefit of the United Engineering Societies." Then Mr. Carnegie retold it to the audience. Some more modesty!

(John Powers bold to us confess'd
He'd cast these lines from off his chest,
Feeling sure that we would need 'em
For our readers. Readers, read 'em!)
TO THE CHIEF
By John Powers

John and I, your two best men, are trying very hard to learn
How to heat these mills up nights with some coal that will not burn.
We keep hustling all the time—we are always on the jump—
But the little steam we get will just run the smallest pump.
If you say it can be done, we will try to be content.
And we'll keep right on afiring with asbestos and cement!

Good old Mister Efficiency has in his perambulations got a half-nelson on the garbage can. He now knows how long it takes to raise it, lower it, dump it—all done by employing the stop-watch to get the exact seconds. This valuable information has been compiled by the Chicago Public Service Commission—real garbage being used in the test. Here in New York there is record of several unofficial garbage tests, mainly to find out how long it will be before it is emptied. And if Hi Costofliving is not soon swatted beyond resuscitation, we won't be able to afford the luxury of garbage.

Confidence and esprit de corps are tremendously valuable assets to any organization.—"Engineering Record." According to our tell, some kinds of confidence people will bear watching. Our dragnet is still out for the corpse of that guy D. Esprit. If anybody in the neighborhood has observed Esprit, tell Kelly about it.

If you can find the humorous side of your worries there is lots of fun ahead of you, says "Wood-worker." Same thing about getting mad (or angry). Who the deuce cares? Laugh at yourself and get some fun out of it. Humor is Father Time's one big hint to longevity.

This is a true story. Once upon a time a Jersey fireman took a civil-service examination in the hope of being placed on the list of eligibles. The examiner regarded him with favor and asked if he would care to go to Overlook, an insane asylum maintaining its own power plant.

"But I'd have to be examined first, wouldn't I?" said the fireman.

"Well, I am the examiner."

"I know you are, but you're not a physician, are you?"

A writer in a machinists' paper says a machini t went to work in a shop as a lathe-hand, and for several days did not know the name of the firm, neither did he like to awsk. Now mark the subtlety, the perspicacity, of this master mind. The third day he glawnced up from his machine and—what do you think?—he saw the firm-name on the ashcan! But suppose some blighter had pinched the ashcan! My word, Watson, I'll work up this case myself.

It leaks out that Sir Joseph John Thomson has discovered a new gas, though he claims no importance for it. Quite so, Sir Joseph. The important thing is to discover a new gas meter, our present one being harder to beat than a hard-boiled egg.

Taking advantage of the parcels post, a well-intentioned individual sent us a 11-lb. hunk of exploded boiler as a souvenir. If this is trying to get hunk with us, we acknowledge the hunk. What we think is nothing to what the postman said when he brought it. Perhaps the w. i. i. has mixed our home address with that of the foundry down stairs.

Power Plant Chemical Laboratory Practice*

This report deals with the testing of only the chief materials used in power work, namely, coal, water and oil.

A list of questions was sent to 91 electric-railway companies. These questions were designed to bring out the extensiveness of the present use of the chemical laboratory in power work; the methods followed in laboratories at present in operation, and the materials tested.

The methods employed by five different companies are described in the report. Following is one of these descriptions:

METHOD EMPLOYED BY UNITED RAILWAYS CO., ST. LOUIS

The following apparatus is required for making a proximate analysis:

Balance, sensitive to 0.1 milligram	$65 00
Weights, analytical—50 grams to 1 milligram	15.00
Platinum crucible with cover, 0.8 gram	15.00
Iron ring stand	0.75
Bunsen burner and tube	0.50
Oxygen cylinder	20.00
Desiccator with porcelain plate	2.00
Parr calorimeter, electric ignition	75.00
Motor for calorimeter	5.00
Drying oven	7.50
Extra rubber and glass tubing, tongs, sample bottles, etc	5.00
Sieve with cover, 100 mesh	2.50
Steel mortar	2.00
Braun Chipmunk crusher	60.00
Pulverizer	25.00
	300.25

The following apparatus is required for making the sulphur determination:

Two beakers, 300 c.c	$0.50
Two watch glasses	0.25
Two funnels	0.50
Quantitive filters 11 cm.	
Stirring rods	
10 per cent. Ba Cl_2 solution	5.00
Concentrated hydrochloric acid	
Weak solution AgNO$_3$	
Sulphur photometer (Parr)	35.00
	$41 25

Three samples are taken from each car shipment to determine the proximate analysis for the amount of moisture, volatile matter, fixed carbon and ash.

Moisture—A 10-gram platinum crucible is weighed, putting the lid on the pan and placing the crucible on it. A 1-gram weight is placed on the weight pan of the balance and the coal sample is then added or taken from the open crucible until the balance is in equilibrium, thus introducing and weighing the 1-gram sample used for the approximate analysis.

The crucible containing the weighed sample of coal is placed in an air oven with the cover off, and allowed to remain one hour, the temperature of the oven being kept at 105 to 110 deg. C.

The crucible is removed after remaining in the oven an hour, put into a desiccator over concentrated sulphuric acid, allowed to cool for a few minutes and then weighed. The difference in weight between the first and second weights equals the moisture.

Volatile Matter—After determining the moisture the crucible containing the dry coal is put on a clay triangle so placed that the crucible will be 6 to 8 cm. above the top of a bunsen burner. The burner is adjusted so that it gives a flame about 20 cm. high, and is placed under the crucible so that the flames envelop the crucible and the latter is thus heated for 7 min. in a place free from drafts. (Any carbon collecting on the outside of the crucible should be burned off.) After cooling the crucible is

*Excerpts of "Appendix B" of report of Committee on Power Generation presented at the convention of the American Electric Railway Engineering Association, Oct. 7 to 11, 1912.

weighed, and the difference between second and third weights equals the volatile matter.

Fixed Carbon and Ash—The crucible containing the remaining material from the determination of volatile matter is heated until the coke is red hot at the edge. Then a slow stream of oxygen gas from the tank is passed into the crucible through a small metal or glass nozzle until all carbonaceous matter is burned. The oxygen must be used very carefully or mechanical loss will result from small ash particles being thrown from the crucible. As a test of complete combustion the crucible is reheated and oxygen again passed into it. The crucible is then cooled and weighed. The difference between the third and last weights equals the fixed carbon. The difference between the weight of the empty crucible and last weight equals the ash.

The ash determined by the above method is usually lower than the ash as determined by the method recommended in the "Report of the Committee on Coal Analysis." This difference is probably due to the complete removal of CO_2 from the ash by the above method, which in the coal was combined with calcium in the form of $CaCO_3$ or limestone. The method given in the report of the committee does not completely decompose the $CaCO_3$; hence the difference.

B.t.u. Determination

Another sample of 0.5 gram is taken from the bottle containing the 100-mesh sample. Should the moisture content of this sample be over 3.5 per cent., as determined by the proximate analysis, the weighed sample is placed on a watch glass and put in the oven where it is kept at 105 deg. C. for about half an hour; by this treatment the moisture will be reduced enough to allow the B.t.u. determination to be made. A Parr standard calorimeter is used, manipulation being made as given in the directions furnished with the instrument.

Sulphur in Coal

The residue is carefully removed from the bomb of the Parr calorimeter to a clean beaker covered with a watch glass. The bomb is carefully rinsed into the beaker with hot water from a wash bottle. The beaker is then covered with the watch glass and 30 c.c. of concentrated hydrochloric acid is slowly added, keeping the beaker well covered. After the reaction has ceased the solution should be acid. This solution is filtered to remove any foreign particles, and the residue is well washed with hot water until the filtrate amounts to about 200 c.c. The filtrate is heated to boiling, then keeping just below the boiling point, 10 c.c. of a 10 per cent. barium-chloride solution is added very slowly (taking 8 to 10 min.) with constant stirring, through a pipette or other device. After heating and stirring for 5 min. more, the solution is set aside. When barium sulphate has settled well the liquid is decanted through an Ashlers filter, the precipitate is washed several times with hot water by decantation, transferred to the filter and washed until the washings are free from chloride.

The moist filter is placed in a weighed crucible, the moisture driven off with a very small flame, charred slowly, then the heat increased until all carbon is removed. It is next cooled and weighed. The weight of barium sulphate multiplied by 2 (for 0.5 gram was taken) multiplied by 0.1373 equals the sulphur in 1 gram of coal.

For a more rapid method the Parr sulphur photometer may be used. The directions sent with the instrument are followed.

Analysis of Ash

Samples of ash are treated the same as coal, the ash is sampled and pulverized to pass a 100-mesh sieve.

Moisture, volatile matter, fixed carbon and ash are determined in the same manner as with coal. Care must be used, when working with ash, to burn out all the carbon present, there being so much mineral matter, traces of carbon may be left in the ash residue.

In making the B.t.u. determination on an ash, should the combustible matter be so low that the charge does not ignite, benzoic acid is used along with the ash to help the combustion.

Several blanks are run with benzoic acid alone, 0.25 gram being a good amount to use. Then a sample is run with the same weight of benzoic acid but with 0.25 or 0.5 gram of ash added. Then, subtracting the temperature rise due to the added benzoic acid from the total rise due to benzoic acid plus ash, the rise due to ash is obtained from which the heat value is calculated in the usual way.

Oil Testing

The methods of oil testing employed by two companies are described in the report, but as they closely follow standard methods, specific description is not given.

Several types of viscosimeters are in use, but comparable results cannot be got with them even when of the same make. This is not a serious defect, however, for what is wanted in any case is only a comparison between the delivered oil and the oil of the guaranteed grade. If it is desired to compare an oil furnished to another company with an oil being used in one's own service, the simple expedient is to secure a sample and run it on one's own viscosimeter.

In answering the questions sent out in regard to oils, many companies replied that the only tests made on oils were service tests. While it cannot be denied that service tests are perhaps the only tests that will select an oil suitable for the service, still, after having made the service tests and determined the characteristics of the oil in the laboratory, it is simple to check the deliveries from time to time and determine whether oil of the guaranteed quality is being received. It would thus be possible to reject an inferior oil before it had been used and possibly prevent thereby much damage to the machinery. The simple oil tests would do this.

Some companies use a friction-testing device, with which the lubricating quality of an oil can be determined. This apparatus is no doubt of value in testing oils for bearings, etc., and the conditions of service can be closely duplicated with it. The only test to determine the entire suitability of a cylinder oil, however, is to test it under actual working conditions in the cylinder.

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A number of representatives from engineering organizations in Boston and the vicinity met on Friday evening, Jan. 10, to consider the advisability of organizing a league for mutual protection against the aggression of the central station. W. K. Campbell was elected president pro tem. and Edward DeGruchy, secretary. Invitations will be extended to all organizations and individuals interested, and a permanent organization effected at an early date.

Annual Meeting of the Heating Engineers

On Jan. 21, 22 and 23 the American Society of Heating and Ventilating Engineers held its nineteenth annual meeting in the Engineering Societies Building, New York City. Some interesting papers and a number of committee reports which should prove valuable were presented. On Tuesday afternoon the first session was opened by acting President John F. Hale, who referred briefly to the conduct of the affairs of the society and immediately after read President Allen's address, which was written within hearing of the guns of the Balkan war. Prof. Allen realized that there was still much to be done even in the elementary development of the science of heating and ventilating and outlined some experimental work which might be profitably carried out by the society. Data on the heat losses in various forms of building construction used in this country, and particularly the newer forms of construction, such as hollow tile, hollow cement bricks, reinforced concrete, etc., would be of particular value. The proper temperature at which the air in a room should be maintained should be scientifically studied, and there is still much need for the development of a more comprehensive method of determining the amount of radiation necessary to heat a given building. The formulas at present do not include many factors which enter into the problem, and to check existing rules it will be necessary to have available, data obtained from actual installations in daily operation. The lack of such information at the present time is very noticeable. Even less is known about ventilation than heating and on this subject there is a great field for experimental work which must be done jointly by the engineer and the physiologist. What constitutes pure air? What are the safe limits of purity? At what temperature should air be used for ventilation? And many others are the questions which must be answered. The president recommended a closer relation between the society and the various laboratories throughout the country where this work might be carried on and an intimate association with the members of the medical profession and physiologists.

Routine business in the shape of reports by the secretary, treasurer, board of governors; Illinois, Massachusetts and New York Chapters and by various committees occupied the balance of the session. The secretary reported an increase in membership for the year of 24, making a total of 449.

The committee on tests consisting of three members reported individually. The investigations of L. C. Soule, chairman, had been limited to the relative efficiency of pipe coils and cast-iron radiation in fan blast heating. Given the same conditions the same amount of heat was transmitted with either kind of surface. The data obtained will be incorporated in a paper for the summer meeting.

James A. Donnelly gave a report of the trip which members of the New York and Boston chapters recently made to the testing laboratories of the H. B. Smith Co., Westfield, Mass., the Sheffield Scientific School of Yale and the International Y. M. C. A. gymnasium at Springfield. On Thursday he also submitted some suggestions on a standard method of testing radiator steam traps or return-line vacuum-system appliances.

The third member of the committee, Prof. L. A. Harding, outlined the work he had done on determining the loss of air pressure in ducts of 6, 9½ and 23 in. in diameter. The tests were conducted under commercial conditions and with velocities ranging from 1500 to 2500 ft. per min. Prof. Harding had also made investigations on heat transmission through building materials. The data had not been arranged for publication, but at a later date will be presented in these columns.

On Tuesday evening the election of the following officers was announced: President, John F. Hale; first vice-president, E. F. Capron; second vice-president, A. B. Franklin; treasurer, James A. Donnelly; board of managers, F. T. Chapman, Ralph Collamore, D. D. Kimball, W. W. Macon, J. M. Stannard, Theodore Weinshank. According to the constitution the two past presidents, Prof. J. R. Allen and R. P. Bolton, are also members of the board.

C. E. Beery read the first paper of the meeting on a system of downward ventilation employed in the Hall School of Rockford, Ill., which is built of brick with wood floor construction. The system consists in part of a series of pipe coils suspended 20 in. below the ceiling, where a maximum temperature of 85 deg. is maintained. Air for ventilation is warmed by vento stacks in the basement and enters the room at a temperature never above 73 to 74 deg., through a double diffuser, to break the current, just below the warm stratum of air at the ceiling. With an air vent in each corner at the floor, a downward air movement is produced at a velocity approximating 2 ft. per min. The rooms heated in this manner are remarkably free from air currents or drafts and up to date the system has given excellent satisfaction. The paper in fuller detail will be published in a later issue.

Frank Irving Cooper read a paper on "Improved Air Conditions in a Boston Residence." The installation consisted of electric radiators, which a low rate for current made feasible, humidifying and air-washing apparatus and a machine for supplying ozone in the amount desired. The electric heater was designed to heat 200 cu.ft. of air per min. from 0 to 70 deg. F. and was automatically controlled.

A committee report on schoolroom ventilation was then read by Mr. Cooper. It was supplemented by an extended report by Charles F. Eveleth on humidifying air at the Oliver Wendell Holmes School in Boston.

On Wednesday morning the session was opened with a paper on "The Design of Indirect Heating Systems with Respect to Maximum Economy and Operation," by Frank L. Busey and Willis H. Carrier. The object of the paper was to show that there is a definite relation between the cost of power and the cost of the apparatus, and to determine what ratio between these two factors will give the best results. The authors presented a number of interesting charts bearing on the subject and worked out some practical applications of the principles advanced.

In conclusion it was stated as regards the heater that the most economical point will be reached when the installation is so proportioned that the yearly cost of power due to the frictional resistance of the heater amounts to 28.6 per cent. of the annual interest and depreciation allowance on the first cost of the heater, this

being true regardless of variations in the depth of heater, temperature rise or steam pressure.

Through the piping or conduits the most economical velocity is such that the annual cost of power due to the piping resistance is one-third of the annual allowance for interest and depreciation. This allowance may be assumed to be about 25 per cent. on the original cost of the installation.

While the lower velocities and consequently lower resistance would require the use of larger fans to operate at high efficiency, considering the entire installation of heater, piping and fan, the annual cost of power should be practically 30 per cent. of the total annual allowance for interest and depreciation. If this allowance is taken at 20 per cent. as an average it would give 6 per cent. on the first cost as the most economical yearly rate to be allowed for power.

Dr. M. W. Franklin talked entertainingly on ozone and its application. He pointed out that ozone had been used with success as a deodorizer in tanneries, glue and fertilizing plants, tunnels and the like where any amount of ventilation would not obviate the nuisance in or outside of the plant. It was also of advantage as a supplement to ventilation in overcrowded factories where the usual amount of air per person is not available.

In the evening the annual banquet of the society was held at the Hotel Martinique, with the newly elected president, John F. Hale, presiding. Mrs. Florence Kelly, secretary of the National Consumers' League, made a plea for the wider dissemination of knowledge on heating and ventilation and for the appointment of intelligent factory inspectors. John Martin, of the Board of Education of New York City and chairman of the committee appointed some time ago to investigate the heating and ventilating of New York schools, spoke of the conditions existing in the city and the desirability of designing ventilating systems so that they might be supplemented by opening windows.

At the session on Thursday morning, Frank K. Chew, editor of the *Metal Worker, Plumber and Steam Fitter*, read an interesting paper on a combination warm-air and hot-water system for heating and ventilating a residence. The space to be heated amounts to 22,057 cu.ft. and the exposure to an equivalent of 1212 sq.ft. of glass surface. The furnace is of the hot-air type, with a hot-water drum having 5.5 sq.ft. of surface in the combustion chamber. Full details of the furnace and of the services in general are given in the paper.

Frank T. Chapman, chairman of the Committee on Ventilation of Motion Picture Theaters, was then given the floor to read his report item by item for discussion by the convention. The principal requirements were a minimum of 4⅓ sq.ft. of floor area as a seating space per occupant, a minimum of 80 cu.ft. of air per occupant and a temperature ranging between 62 and 70 deg. F. Specific directions were also given for machine-booth ventilation.

One of the topics for discussion brought up at the last session of the convention was a request for a standard method of using an anemometer in measuring air velocity in front of a register. A committee had been appointed, which reported as follows:

Divide the opening into eight equal rectangular areas with no side longer than 10 in. Where the opening is larger than the maximum obtainable with these figures, use twelve areas. Readings of one-half minute duration are to be taken at the center of each area. The average of the readings is to be taken as the average velocity. Any negative reading due to a dead space in the register is to be deducted. The average velocity times the net area of the opening will equal the volume of air discharged. When the anemometer is held 2 in. from the face of the register no allowance need be made for the iron or wire mesh, the full area of the opening being taken. With a diffuser the total area is to be that contained within the outer perimeter.

In the discussion it was brought out that the anemometer is not an accurate instrument for measuring air velocity in front of registers and should not be used. The pitot tube was better, but in the opinion of W. J. Baldwin, neither instrument permitted of any great accuracy in this work. He recommended the use of a cone-shaped hood and the measurement of the velocity at the apex as a more accurate method.

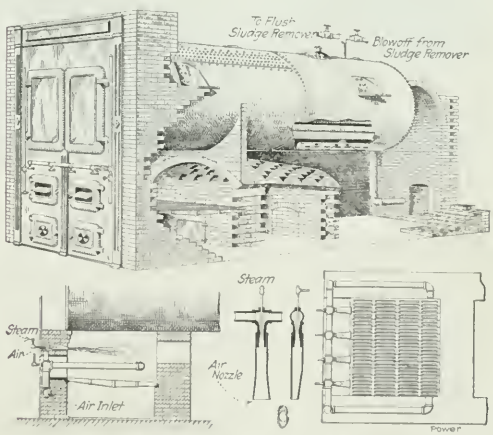
Other matters discussed at this session were Mr. Donnelly's method of testing radiators and a letter from the American Society of Mechanical Engineers requesting coöperation in an addition to be made to the present standard of flanged fittings. A committee was appointed to confer with the mechanical engineers.

Special entertainment was provided for the visiting ladies in the way of sight-seeing tours, automobile rides, luncheons, matinee parties and on Thursday evening opportunity for all was given to attend the Hippodrome.

Broman Oven Furnace

By R. Cederblom

Two furnaces similar to the one shown in the accompanying illustration were specified as part of a complete power plant installed by the writer in a wood-working



Broman Oven Furnace

factory about a year ago. The results obtained from this plant have been entirely satisfactory both in regard to smokelessness and efficiency.

Ordinarily when one or more brick arches are used to obtain smokeless combustion, they are installed with more

or less sacrifice of heating surface unless placed entirely outside of the boilers, which often is objectionable on account of space, loss of heat from radiation, etc. With the construction shown, practically the entire half of the shell is exposed to the flame and hot gases, as they pass through numerous small openings in the top of the arch and come in contact with the metal.

The mixture of air and unburnt gases passes over the bridge-wall, and into a combustion chamber with a solid back and an arch with a number of small perforations, 4x6 in., through which the gases must pass before coming in contact with the shell. It is quite natural that at the high temperature existing in the oven and the gases split up into small volumes in passing through the perforations in the hot brick arch, the combustion should be complete, providing sufficient air is present. It also stands to reason that with such thorough mixing of the air and gases a minimum quantity of air is required for complete combustion, and less heated, free air goes to waste up the chimney.

The combination steam and air nozzles introduced through the front and sides of the furnace are used to supply the extra amount of air required when a fresh charge of coal is thrown onto the grates and at the same time to thoroughly mix with air the gases driven off the fresh fuel before they enter the combustion chamber.

Previous to the writer's experience with this furnace, four of them were installed under 66-in. by 18-ft. boilers constituting part of the power plant of one of the large department stores in Chicago. Originally the boiler plant consisted of six 66-in. by 20-ft. and the four 18-ft. boilers equipped with ordinary grates and settings. During the cold season all of the exhaust steam was required for heating purposes with never less than seven boilers in operation. Shortly after the 18-ft. boilers had been equipped with the perforated arch furnaces, the central station secured the contract for supplying heat as well as power to this building, but not being in a position to supply the heat the first season, the four boilers were retained and readily furnished enough steam to heat the entire building.

The furnace is the invention of J. G. Broman, a mechanical engineer of Chicago, who has given considerable time and study to the subject of combustion.

Engineers' Entertainment at Atlantic City

Association No. 9, N. A. S. E., of Atlantic City, N. J., entertained its many friends at Turner Hall, in that city on the evening of Jan. 11. The national and state officers were assisted by a New York delegation of well known engineer entertainers, including Jack Armour, Joe McKenna, Billy Murray, W. S. Martell, W. S. Leonard, J. W. Greves, John Callahan, Edward Sears, Frank Martin and Frank Tuttle.

President Truman, of the local association, welcomed the visitors and friends. The toastmaster was State Deputy John Jenkinson, chairman of the entertainment committee. After the songs and stories, James R. Coe gave a brief talk on the work of the National Association of Stationary Engineers. Over 100 members and guests attended the banquet.

Boiler Explosion at Howland, Me.

From information received, two of the seven return-tubular boilers of the Howland Pulp & Paper Co., Howland, Maine, exploded at 8:30 a.m., Jan. 20, killing two men, injuring several others, and wrecking the boiler house.

Both men killed were firemen, and were found pinned beneath the wreckage, severely scalded by escaping steam and crushed by flying débris. Both were alive when taken from the wreckage, but one died three hours later and the other in five hours.

The explosion completely wrecked the boiler house and demolished the setting of the remaining five boilers. Two steel stacks were knocked down, one falling on the mill, doing additional damage. The pump house and engine room were wrecked, and flying live coals started several fires which were put out without difficulty.

It is reported that the boilers were 22 years old. They were insured by the Hartford Steam Boiler Insurance & Inspection Co., and were allowed to carry 80 lb. of steam. The loss is reported to be between $40,000 and $50,000.

Among those who escaped death, the most seriously in-

Atlantic City N. A. S. E. Engineers' Banquet.

jured was a fireman, who received three broken ribs and numerous bruises, but is expected to recover.

One large part of the boiler crashed into the mill, adding considerable damage to that done by the falling stack.

Locomotive Boiler Explosion

The explosion of the boiler of a Detroit & Toledo Shore Line R. R. locomotive at Detroit, Mich., Jan. 5, caused the death of one man and the serious injury of six others. The engine was being prepared to haul a passenger train to Toledo when the explosion occurred. A later inspection of the crown sheet disclosed that the plate was buckled between the stays, or forced down from the internal pressure in many places ⅛ in. The effect of the buckling between the stays was to enlarge the threaded holes in the plate, thereby greatly lessening their holding strength. All stays in the crown sheet had been repeatedly hammered up or calked to prevent leakage. The heads which the stays no doubt had originally were almost entirely pounded away. The first thread on the end was apparently destroyed from the repeated hammering.

In addition to the defective stay threads, 41 stays were found to have been broken at some time preceding the accident. The collapse of the crown sheet would not have occurred from the broken stays, if the threads on the balance of the stays had been in good condition, because the broken stays were so located that the curvature of the furnace added much strength.

The boiler bore evidence of great neglect, of long standing, with stay-bolt ends and stays broken, try-cocks dirty and water gage-glass cock partly closed. An ordinary inspection should have disclosed to a competent inspector that this boiler was in an unsafe condition.

It is not evident that the water was low just preceding the accident, and the complete absence of scale on the crown-sheet after collapse does not warrant the belief that the crown sheet was hot just before the collapse, as any scale thereon would have been cracked off by the elongation of the plate after collapse. The scale on the crown-sheet under the crown bars was not in any way disturbed.

More Turbine Trouble on the "Lusitania"

According to press reports of Thursday, Jan. 23, the steamship "Lusitania" is again laid up in Liverpool for repairs to at least one low-pressure turbine. She arrived at that port Dec. 31.

As usual no official information is available concerning the trouble, but it is understood that this lay-up is due to the bursting of the turbine casing, which, it is said, damaged the ship's bottom. The "Lusitania" is indeed unfortunate with her turbines, or at least with a forward port turbine, which seems to be the one giving the most trouble. Early last June a forward port turbine, stuck fast shortly after leaving Liverpool and the vessel continued to New York at reduced speed. About the middle of last August the daily press reported that the same turbine, presumably, had a "hot box," which made so much noise that nearly all on board were wakened. Later, investigation developed that the passengers were wakened by the tearing to pieces of the turbine blades—quite different from a "hot box."

Last November a new port low-pressure turbine was installed, but no official information will confirm the report that this is the one that went to pieces during her late December voyage from New York.

Ohio Examiners' and Inspectors' Report

The report of the work done by the Ohio state examiners of steam engineers and the boiler-inspection departments during the fiscal year ending Nov. 15, 1912, shows:

Applications for engineer's license	2291
Applications for boiler operator's license	1410
Total	3701
Engineers failing to qualify	1149
Boiler operators failing to qualify	388
Total	1537
Engineers qualifying	1142
Boiler operators qualifying	1022
Total	2164
Engineers' licenses revoked	3
Engineers' licenses expired	690
Boiler operators' licenses expired	271
Total	964
Engineers' licenses renewed	12,775
Boiler operators' licenses renewed	1,822
Total	14,597
Engineers holding licenses	13,917
Boiler operators holding licenses	2,844
Total	16,761
Receipts from examination and renewals	$36,596.00
Maintenance expenses	29,557.23

There were 14 employers and 18 operators convicted of violations.

A census taken of the steam plants in the first, second and seventh districts, which include Cincinnati, Cleveland and Toledo, by the board of steam engineers' examiners, shows the benefit derived from convictions against violators, the increased number of licenses issued, and the consequent increased protection afforded the public.

The law creating the boiler-inspection department went into partial effect on Jan. 1, 1912, but did not become fully effective until July 1. The following report covers about seven months:

State inspections	1,980
Insurance inspections	11,670
Boilers registered and certified	12,150
Boilers held for repairs	302
Boilers condemned and out of service	198
"Ohio Standard" boilers built and approved since July 1	702
Boiler manufacturers registered and authorized to build "Ohio Standard" boilers	59
Applicants examined to qualify as boiler inspectors	170
Qualified	146

From the list of those who qualified, ten inspectors were commissioned to act as "general inspectors" in the state service and 104 as "special inspectors" in insurance service.

Three boiler explosions, in which three persons were killed and one injured, were reported. Four explosions, killing four persons and injuring 11, occurred on boilers not covered by law.

For a Museum of Industrial Arts

The value of museums as educational factors has been recognized by the foremost nations of all civilizations, but the great works of the engineer and mechanic built upon scientific research have thus far had but scant recognition.

Germany has erected the first comprehensive museum of the masterpieces of science and the technical arts at Munich. In less than five years its marvelous success encouraged the managers to invest the millions supplied by German industrialists in a permanent building on an island in the Isar, now nearing completion. Last April a commission of five, with as many engineer assistants, was sent to this country to look for more contributions of machines, models, drawings, etc., to enable it to add an American section to each of the main divisions and to encourage American engineers to begin a similar movement.

America owes its greatness to the courage and skill with which its artisans and engineers solved the gigantic problems which the conquest of a new continent imposed, and it is this generation which has profited by the labors of the pioneers and which should search out and preserve the records of their work.

Nearly thirty years ago, John E. Sweet, past president of the American Society of Mechanical Engineers, wrote: "May the time come when we shall have a museum in which there shall be gathered the finest specimens of workmanship with the masterpieces of our great engineers."

It is to be hoped that every man familiar with any one of the many industries will search out such relics as still exist in drawings, models, descriptions or specifications and,

once used but now outclassed or outworn tools, machines and structures which represent steps in industrial progress, rescue them from the oblivion of the scrap heap and notify the committee on museums of the American Society of Mechanical Engineers of their existence, condition and location, and explain to the present owners their educational and sentimental value. This knowledge of what is available for preservation must precede the planning of any building to house them and will largely aid in inducing cities, corporations, and individuals to proffer the financial aid necessary to build up some great national museum of the industrial arts. The movement once begun and its educational value made manifest, other museums will grow up in various communities illustrating special industries.

Dr. Kunz, who is also chairman of the plan and scope committee for the celebration of the century of peace between England and America, has proposed such an industrial museum as the fittest expression of American pride and joy in this achievement.

Dinner to C. A. Griscom, Jr.

The rapid growth during the past year of the Griscom-Russell Co., the successor to the Griscom-Spencer Co., Russell Engine Co. and the James Reilly Repair & Supply Co., was celebrated by a dinner given to President Clement A. Griscom, Jr., by the G-R Lunch Club, at the Garret Restaurant, New York City recently. It completed Mr. Griscom's first year in the active management of the business, and his twenty-first as president.

Nearly one hundred members of the staff attended, including the New York sales, engineering and accounting forces, and the cost and office staff and foremen from the Jersey City shops. The works at Massillon were represented by Arvine Wales and R. J. Pabodie, M. E., works manager. G. V. S. Michaelis, vice-president and treasurer, was toastmaster.

Educational Work of Beacon Association No. 30, N. A. S. E.

Herewith is presented Question Paper No. 5-B issued by the Educational Committee of Beacon Association No. 30, N. A. S. E., as illustrating the good work being done by operating engineers for their mutual improvement. The questions reflect the earnestness of the members of the association and are not only of technical interest, but should be appreciated by owners of power plants in evidence of the breadth of intelligence which engineers are called upon to exercise in the practice of their vocation.

The question paper is as follows:

1. How is the manhole plate made, and how put in, when a boiler has a circular manhole opening?
2. Describe a gusset stay. In what type of boiler is it used? Is there any objection to its use in a horizontal tubular boiler?
3. Why does the Board of Boiler Rules object to the use of a lead manhole gasket below the water line?
4. How is the underneath part of Heine boilers got at for inspection?
5. Why are the fire tubes of vertical boilers of smaller diameter than those of horizontal tubular boilers?
6. If the water line in a vertical boiler is located at a height of $\frac{2}{3}$ the length of the tubes, will the capacity of the boiler be increased, or decreased, if the water line is raised? Explain why.
7. Where is the circulating pipe attached to a vertical Cahall boiler and what is it for?
8. What is the thickness of the metal in B. & W. boiler tubes? Would there be anything gained, or lost, if the metal in these tubes was made twice as thick?
9. What part of the boiler has the greatest pressure on it? Why?
10. If a Massachusetts standard boiler, horizontal tubular type, has a manhole in the front head beneath the tubes, will both heads of that boiler beneath the tubes require bracing? Give the reasons for your answer.
11. What is gained by the use of an economizer? Where should it be located? What troubles are liable to arise through its use?
12. Why do injectors refuse to work when the feed water is too hot?
13. If one of the springs of a Waters governor should break while the engine was running, what would happen?
14. What horsepower will a man weighing 180 lb. develop in walking up a flight of stairs 100 ft. high in one minute?
15. What is meant by "The Range of the Governor?" Do all governors have the same range, if not, why not?
16. Why is the solid piston generally used in preference to the built up piston in high-speed engines?
17. Which do you consider the better connection for a piston rod in a crosshead, the screwed end with check nut, or the keyed tapered end? Why?
18. Why is the cutoff of a plain slide-valve engine limited to about $\frac{7}{8}$ stroke when some balanced slide-valve engines cut off much earlier in the stroke?
19. A Rice & Sargent engine has a sliding foot; what for?
20. Why should a Corliss engine use less steam per indicated horsepower than a slide-valve engine?
21. Draw an indicator card, such as would be taken from a Westinghouse compound engine and explain the same.

SOCIETY NOTES

The annual meeting of the American Institute of Consulting Engineers was held, Jan. 14, at the Engineers' Club, New York City. Henry Holgate, Montreal, Canada, and Daniel E. Moran and Charles Sooysmith, New York City, were elected members of council to serve three years. F. A. Moliter, New York City, was elected a member of council to serve one year. After the routine business was transacted, Prof. George F. Swain, of Harvard University, addressed the meeting on the question of 'Education," which was very ably discussed by Rudolph Hering, Gen. T. A. Bingham, Prof. Gardner S. Williams, of Ann Arbor, Mich., and Frank J. Sprague.

The Interstate Oil Mill Superintendents' Association will hold its convention in Atlanta, June 4, 5 and 6, at the Auditorium Armory. The plans include the most comprehensive exhibit of oil-mill machinery and appliances ever held in the South and the main room of the auditorium has been reserved for the exhibits. Both operating and still exhibits will be shown and an attendance of 250 oil-mill superintendents is expected. J. C. Holmes, president of the Interstate Oil Mill Superintendents' Association, Shellman, Ga., will give information relative to the superintendents' meeting, and F. C. Myers, secretary of the Oil Mill Superintendents' Auxiliary, has complete information in regard to exhibit space and the exhibitors' association.

OBITUARY

LAVINIA MARSTON SWASEY

Mrs. Lavinia Marston Swasey, wife of Ambrose Swasey, president of the Warner & Swasey Co., Cleveland, Ohio died at her home, 7808 Euclid Ave., on Jan. 22. Mrs. Swasey was born at Hampton, N. H., July 28, 1842, the Marston family having been among the pioneer settlers of that community.

Mrs. Swasey had lived in Cleveland for more than thirty years and was well known in society, in benevolent work, and to members of the American Society of Mechanical Engineers and their wives, having frequently attended the meetings. She was also active in the Young Women's Christian Association, and was selected by its founders as one of the original Rose Fund trustees.

Wide experience of travel in many parts of the world had broadly extended Mrs. Swasey's sympathies in lines of missionary effort, and the hospitalities of that home, as well as the presence of its gracious mistress, will be missed by a large number of friends.

PERSONALS

F. D. Martin, consulting engineer, has been retained to prepare preliminary estimates for a municipal electric-light plant at Fort Scott, Kan.

Heinrich Homberger, consulting engineer, 864 Pacific Building, San Francisco, has been appointed advisory engineer for hydraulic-plant equipment by the Oro Electric Corporation in connection with the proposed 40,000-kv.-amp. power plant on the North Fork of the Feather River.

POWER

Vol. 37 NEW YORK, FEBRUARY 11, 1913 No. 6

EXAMPLE IS BETTER THAN PRECEPT

Waterbury and Bull's Bridge Plants

By Warren O. Rogers

SYNOPSIS—The Waterbury plant consists of four steam turbine units and a large transformer station. The latter converts the electrical energy generated at the Bull's Bridge hydro-electric plant and the steam turbines to voltage suitable for commerical use. The Bull's Bridge plant contains six 1000-kw. hydro-electric turbo-generators.

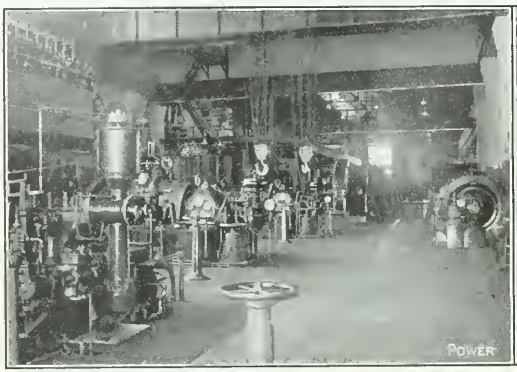


Fig. 1. Turbo-generator Room from the Turbine End

Fig. 2. Generator Room from the Transformer End

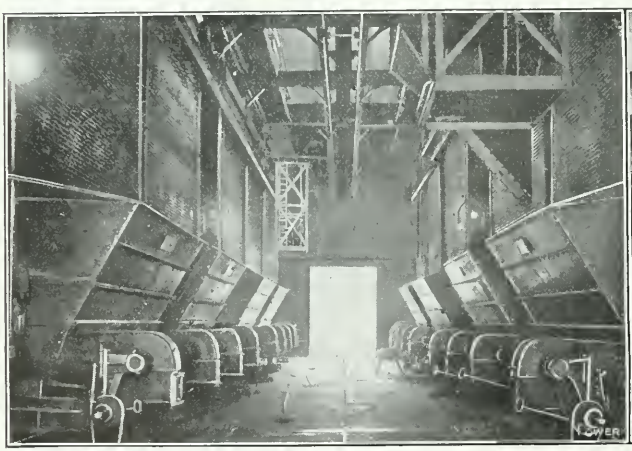


Fig. 3. Eight 500-hp. Water-tube Boilers

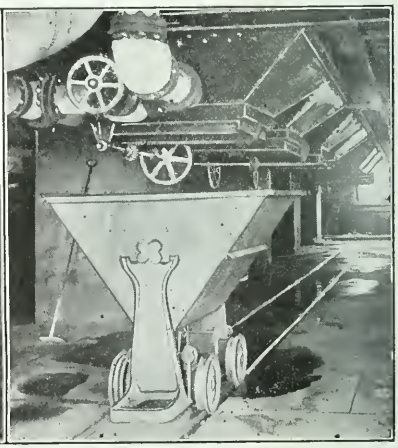


Fig. 4. Ash Car in Boiler-room Basement

What is now known as the Waterbury turbine plant of the Housatonic Power Co., Waterbury, Conn., was originally a substation, used for transforming the electrical energy generated at the hydro-electro station of the company located at Bull's Bridge, Conn., to commercial voltages.

The older part of the building is still used to house transformers of various types, and rotary converters for railway load, but the new extension in which the turbine-driven generators are installed forms a continuation of the transformer room. This enables the operators to have an unrestricted view of the entire electrical equipment.

Turbines and Condensers

In many respects the steam-generating plant is a duplicate of the power plant recently built at Zylonite, Mass., and described in Power, July 4, 1911. There are three steam turbines, placed crosswise of the generator room, Fig. 1. The largest is of 3000 kw., running at 1800 r.p.m. The other two turbines are of 1500 kv.-a. capacity, running at 3600 r.p.m. All use steam at 175 lb. pressure, superheated 75 deg. F. Each turbine exhausts into a jet condenser. The larger unit is supplied with condensing water by a turbine-driven, 20-in. volute pump and each small turbine condenser by a turbine-driven, 12-in. volute pump. The speeds are 970 and 1750 r.p.m.

and the turbines are of 125 and 25 hp., respectively, at 175 lb. steam pressure. The large condenser is piped to a 12 and 22 by 18-in. steam-driven dry-air pump; the other two condensers are each connected to an 18 and 20 by 12-in. steam driven dry-air pump. Work is also under way in installing another steam turbine of 4000 kw. capacity.

These auxiliary units are in the basement between the concrete columns forming the supports for the turbines. Steam superheated 75 deg., at boiler pressure, is used on all auxiliaries.

All condensing water is taken from the Naugatuck River, which flows past the plant.

Directly coupled to the large turbine is a 3000-kw., alternating-current, three-phase, 60-cycle, 2300-volt generator. The small turbine generators are of 1500 kw.-a. capacity; the voltage is 2300 and the amperage 373 per terminal.

Exciter Units

There are two 125-volt turbine-driven exciter sets, each of 100 kw. capacity at a speed of 1800 r.p.m. These units are placed lengthwise at one side of the room, Fig. 1, and at the head end of the turbines. There are no motor-driven exciter units, as the exhaust steam from the auxiliary turbine can be used to advantage in heating the feed water.

Boiler Room

The eight 500-hp. water-tube boilers are in a room built on the back of the extension to the old transformer station, and are in four batteries of two boilers each, as shown in Fig. 3, with a firing alley between the two rows. The furnaces have mechanical stokers operated by chain drive from a shaft running under the stokers in the basement. This shaft is belt-driven from the blower turbine, also in the basement. The boilers are all equipped with superheaters.

Draft Control

For the draft there are two forced-draft fans, each driven by a 150-hp. turbine. These are in the basement and the air is delivered to a sheet steel air duct running beneath the boiler furnaces. Four outlets extend from the top, each dividing into a Y, making eight branch pipes, which are extended to the ashpit of the eight furnaces. The speed of the turbines driving the forced-draft fans is controlled by a steam damper regulator. The uptake damper is controlled by a regulator actuated by the air pressure in the furnace.

In a room above and at one end of the boiler room are four 12-ft. fans, each driven at constant speed by a side-crank, slow-speed, piston-valve engine. The flue gases from each set of four boilers pass through an economizer back of each set of boilers. After passing through the induced-draft fans the gases are discharged through two

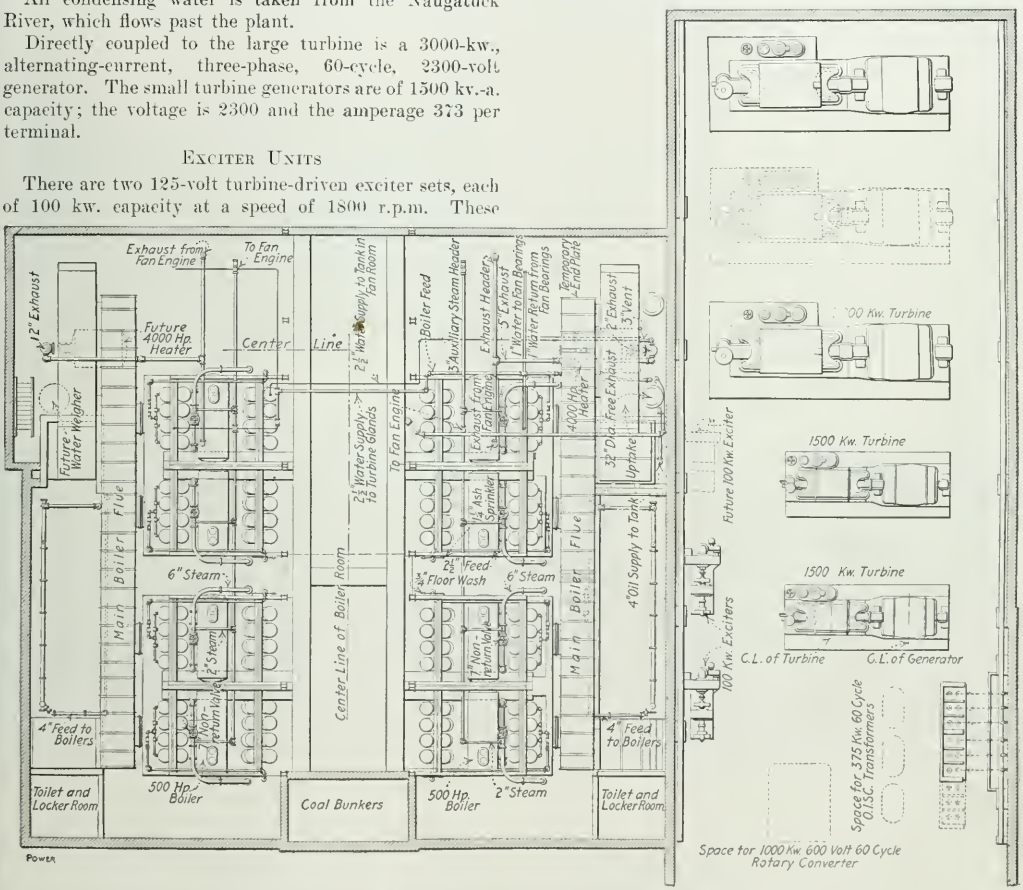


Fig. 5. Plan of the Waterbury Turbine Plant

10-ft. stacks. A 3-in. draft is created by the forced-draft fans, but the induced draft is much less, varying from 0.3 to 0.5 in. A third forced-draft fan is also installed, driven by a 600-volt direct-current motor of 50 to 100 hp. capacity, running at 80 to 960 r.p.m.

Feed Water

Water for boiler feed is pumped from the Naugatuck River by a 14 and 12 by 12-in. duplex pump in the turbine-room basement. The feed water is pumped through an open feed-water heater, and a water weigher to two iron hotwell tanks in the basement from which it is pumped through the economizer to the boilers by either of four

wheel, shown in Fig. 4. When the ash hoppers are to be emptied, an ash car is run under the gate and after loading is run out and dumped in the yard, which is on a level with the basement floor. The space beneath the conveyor is used for storing coal, which when wanted is shoveled into a small coal car and run to the conveyor hopper on a track. A monorail coal handling system, for reclaiming coal from the storage pile, is now being installed.

The old section of the present building is used as a substation, containing the necessary step-down transformers and rotaries, for supplying the railway circuits, and the necessary step-down transformers for reducing the

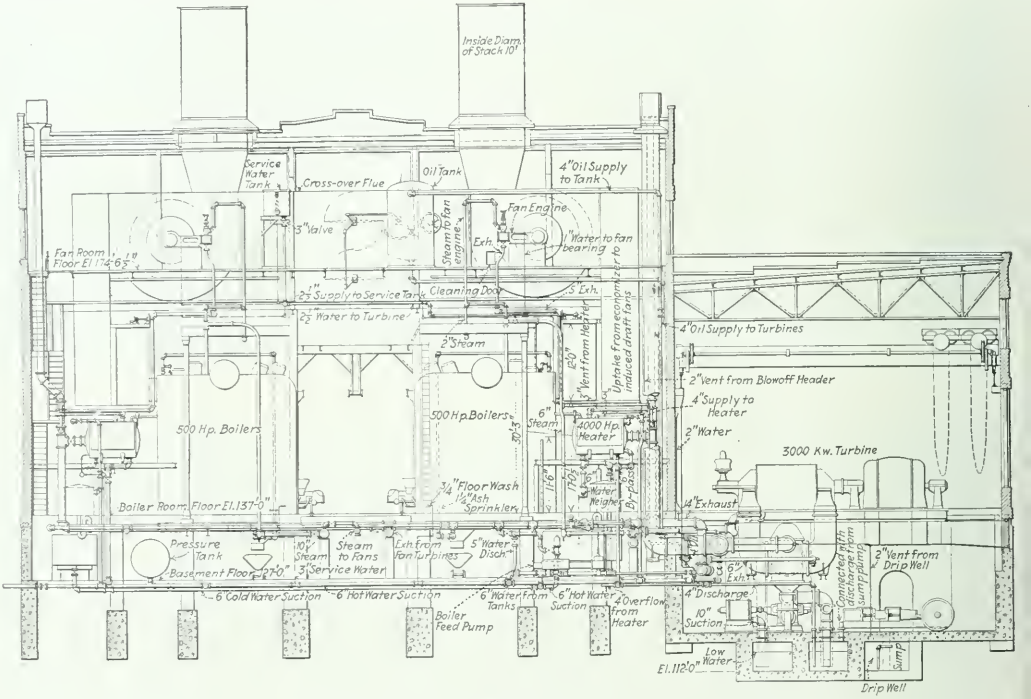


Fig. 6. Section through Waterbury Turbine Power Plant

12 and 7 by 18-in. outside-packed duplex, pot-valve pumps.

Coal and Ash

Coal is delivered to the boiler-room coal-storage bin by a scraper conveyor from a hopper below the ground surface in the yard. The fuel is dumped through the bottom of hopper cars into the conveyor hopper and is carried to the 75-ton coal service bunker at a rate of 40 tons per hour, passing through a set of crushing rolls. Fuel is transferred from the service bunker to the stokers by two electrically operated traveling weigh hoppers, each of 5-ton capacity. Each weigh hopper has a spout through which the coal is delivered to the stoker hoppers, and scales for weighing the coal.

Ashes from the stokers drop into ashpit hoppers having slanting sides and sliding bottom plates which are opened or closed by a rack and pinion operated by a hand-

transmission line voltage from 33,000 to 2300 volts for distribution to the various lighting and power lines.

The railway equipment consists of two 1000-kw., 600-volt direct-current, six-phase, 60-cycle rotaries and two 500-kw., 600-volt, direct-current, six-phase, 60-cycle rotaries, with the necessary transformers for stepping down from 33,000 volts to 440 volts; one motor-driven boosting generator for boosting the voltage on the long outlying lines.

There are two banks of oil-cooled transformers, each consisting of three 600-kw., single-phase transformers delta connected, for reducing the voltage from 33,000 to 2300 volts for distribution to the various lighting and power lines. There are seven constant-current transformers for supply to alternator-current arc circuits. These are complete with necessary individual plug switchboards, as shown in Fig. 2. Each transformer is of the air-cooled type and 500 kw. capacity. The cooling air for air-cooled

equipment is supplied by two motor-driven fan blowers, the normal air pressure being 5⅝ oz.

Part of the oil switches are motor operated and part solenoid operated, the more modern type being the latter. The 33,000-volt switches are located on the main floor between the wall and the transformers. The 2300-volt switches are located in the bus structure in the basement directly under the switchboard. This switchboard consists of a 50-slate panel and is placed along the opposite side of the transformer room from the oil switches before mentioned. Fifteen of these panels are for lighting and power circuits; 12 are for the rotary converters, booster and instrument panels; 13 are 600 volt, direct-current railway feeder panels; six are 33,000 volt high-tension

FIG. 7. HYDRO-ELECTRIC POWER PLANT, BULL'S BRIDGE, CONN.

panels and four are 2300-volt, three-phase generator panels.

The building is of red brick. The boiler room adjoins the new section, the building as a whole being L-shaped. There are two hand-operated cranes, one above the transformer section, and one over the turbines. The first is of 10 tons and the other of 35 tons capacity. A plan and elevation of the turbine plant is shown in Figs. 5 and 6.

HYDRO-ELECTRIC POWER PLANT

Thirty-two miles from Waterbury is the Bull's Bridge, Conn., hydro-electric power plant of the Housatonic Power Co., which is run in connection with the Waterbury steam station. The building is of concrete and has a wing containing the switchboard and transformers. Fig. 7 shows a rear view of the building and penstock. The Housatonic River is dammed at Kent, two miles above the power plant.

The water is taken from above the dam, two miles above the forebay, which is just above the gate-house on the hill, shown in Fig. 7. Here the water is controlled by gates and delivered to the water turbines through a 13-ft. penstock, which is reduced in size at each intake to a waterwheel. The penstock rests upon concrete supporting blocks from the gatehouse to the end of the power house, and upon supporting forms made of I-beams and saddles at the rear of the station, as shown. Water to each of the 2000-hp. hydraulic turbines is controlled by a hydraulic gate valve; a three-way valve in a bypass pipe connects with the top and bottom of the valve cylinder controlling the admission of water to the valve plunger. The three-way cock is operated by hand chains by the operator while standing on the floor.

Each of the six turbines is directly coupled to a 1000-kw. alternating-current generator running at 400 r.p.m. The voltage of each machine is 1150. A general view of the generator room is given in Fig. 8. The shaft of each generator extends out beyond the outboard bearing. This permits moving the bearing out on the base extension and also moving the generator casing sidewise so that the armature is accessible without getting the shafting out of alignment.

Belt-driven waterwheel governors regulate the speed of these turbines, each independent of the other, as shown in Fig. 9.

The two exciter sets are driven by water turbines, each directly coupled to a 125-volt, direct-current generator.

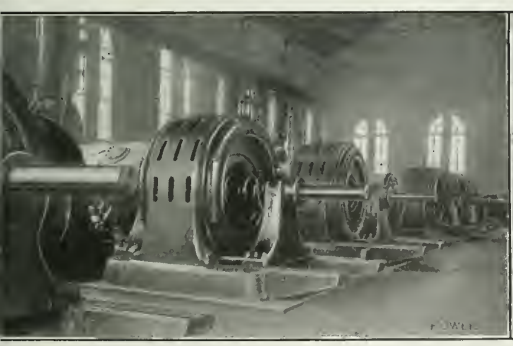


FIG. 8. HYDRO-ELECTRIC GENERATOR UNITS

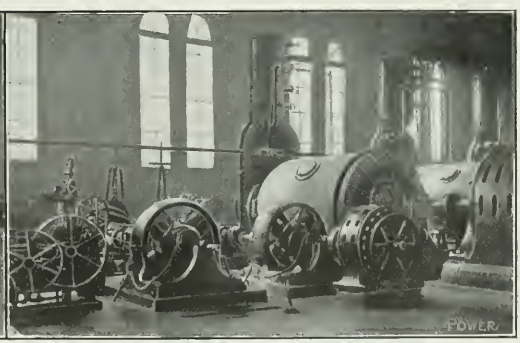


FIG. 9. EXCITER UNITS AND HYDRAULIC GOVERNOR

Connection is made with the main penstock by a 36-in. pipe having a Y-connection at the inner end and an 18-in. branch to each water turbine. One of the exciter units is directly coupled to a 100-hp. induction motor, which is used to operate the exciter generator after the main units have been brought up to speed and phased in. Each exciter unit is governed by a belt-driven hydraulic governor. This is all of the machinery in the hydro-electric plant.

A view of the marble switchboard is shown in Fig. 10. It is on a balcony facing the generator room. Underneath are the motor-operated oil-break switches. In a room back of the switchboard are the seven 850-kw. transformers, Fig. 11, which take the electrical energy at 1150 volts and step it up to 33,000 volts, at which pressure it is transmitted to the Waterbury station over a duplicate

transmission line of 4/0 aluminum wire on wood poles, there being two banks of transformers, with one spare.

The stage of the water in the Housatonic River governs the operation of these two plants. If the water is sufficient to drive all of the six generating sets, the steam-turbine plant is relieved of much of its load, which permits of cutting out some of the boilers, turbines and generators until such time as the state of water at the hydro-electric plant demands the operation of additional steam units to maintain the maximum output of electrical energy.

Although these two stations are about 32 miles apart, they work in parallel, signals for cutting machines in and out of service being given by illuminated disks at the switchboard.

Turbine Driven Centrifugal Pump of Large Capacity

A steam-turbine-driven centrifugal pump of 100,000,000 gal. per day capacity, is to be installed in the Ross pumping station of the Pittsburgh water-works by the DeLaval Steam Turbine Co., of Trenton, N. J.

It is reported that this will be the largest steam-turbine-driven centrifugal pump ever built in this country: the rated capacity is 100,000,000 gal. per day against a total head of 56 ft.

The pump is guaranteed by the builders to show a duty of 115,000,000 ft.-lb. per 1000 lb. of dry steam, all steam used by the condensing equipment being charged to the main unit.

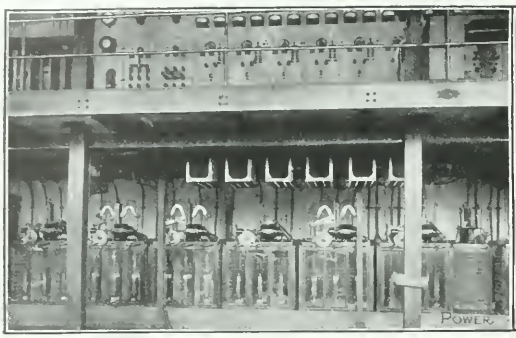


FIG. 10. OIL SWITCHES AND SWITCHBOARD

FIG. 11. TRANSFORMER ROOM

EQUIPMENT OF THE WATERBURY AND BULL'S BRIDGE, CONN., POWER PLANTS

No.	Equipment	Make	Application	Kw.	K.v.a	Volts	Phase	Cycles	Amp. per Terminal	Type	R.p.m.	Size	Pressure lb.	Hp.	
1	Steam turbine	Curtis	Main unit	3000							1800		175		General Electric Co.
2	Steam turbines	Westinghouse	Main units		1500						3600		175		Westinghouse Machine Co.
1	Steam turbine	Kerr	Circ. pump								970		175	125	Kerr Turbine Co.
2	Steam turbines	Kerr	Circ. pump								1750		175	25	Kerr Turbine Co.
2	Steam turbines	Westinghouse	Exciter units								1800		175		Westinghouse Machine Co.
2	Steam turbines	Terry	Fans										175	150	Terry Steam Turbine Co.
2	Generators	A.C.	Main units	3000		2,300	3	60	837	A.T.B.	1800				General Electric Co.
2	Generators	A.C.	Main units		1500	2,300	3	60	373		3600				Westinghouse Electric & Mfg. Co.
2	Generators	D.C.	Exciters	100		125			800		1800				Westinghouse Electric & Mfg. Co.
1	Motor	D.C.	Blower Fans			600			72		480			50	General Electric Co.
									143		960			100	
2	Motors	Induction	Converters			351	3	60	200	R	600			30	General Electric Co.
1	Motor	D.C.	Gen. drive			550			290	M.P.	450			180	General Electric Co.
2	Motors	Induction	Cooling Fans			650	3	60	14	I				7.5	General Electric Co.
1	Condenser	Jet	Large turbine									20"			Alberger Pump & Condenser Co.
2	Condensers	Jet	Small turbines									12"			Alberger Pump & Condenser Co.
8	Boilers	Water tube	Steam gen.											500	Bigelow Co.
8	Stokers	Taylor	Boiler furnaces												American Engineering Co.
8	Superheaters	Foster	Sup. steam												Power Specialty Co.
1	Pump	Dry air	Jet condenser									12x22x15"	175		Alberger Pump & Condenser Co.
2	Pumps	Dry air	Jet condensers									8x20x12"	175		Alberger Pump & Condenser Co.
1	Pump	Smith-vaile	River water									14x12x12"	175		Platt Iron Works.
1	Pump	Duplex	Returns									4½x2½x4"	175		Henry R. Worthington.
1	Pump	Duplex	Oil system									6x7½x6	175		Henry R. Worthington.
4	Pumps	Duplex	Boiler feed									12x7x18"	175		Wilson-Snyder Mfg. Co.
3	Fans	Forced draft													Sturtevant Co, B. F.
5	Fans	Induced draft										12			Massachusetts Fan Co.
4	Regulators	Balanced draft	Boiler furnace												The Engineer Co.
1	Heater	Cochrane	Feed water												Harrison Safety Boiler Works.
1	Heater	Hoppes	Feed water												Hoppes Mfg. Co.
1	Weigher	Wilcox	Feed water												Wilcox Engineering Co.
2	Blowers	Fan	Transformers												Buffalo Forge Co.
1	Converter	D.C.	Generator			200			600	M.P.	450				General Electric Co.
2	Converters	Rotary	A.C.	1000		600	6	60	1667	H.C.	600				General Electric Co.
2	Converters	Rotary	A.C.	500		600	6	60	833	H.C.	600				General Electric Co.
3	Transformers	Air cooled	Trans. lines	600	667	33,000	1	60						½ oz.	Westinghouse Electric & Mfg. Co.
						2,300									
3	Transformers	Air cooled	Trans. lines	600		33,000	1	60		A.B.H				½ oz.	General Electric Co.
						2,300									
6	Transformers	Air cooled	Trans. lines	500		33,000		60		A.B.				½ oz.	General Electric Co.
						440									
7	Transformers	Constant current	Arc circuits	62		2,200			6.6	R.P.					General Electric Co.
9	Transformers	Oil cooled	Trans. lines		300	33,000		60		H					General Electric Co.
1	Crane	Hand operated	Trans. room			6000						20,000 lb.			Whiting Foundry Equipment Co.
1	Crane	Hand operated	Turbine room									70,000 lb.			Brown Hoisting Machine Co.
6	Turbines	Hydraulic	Gen. units								400			2000	S. Morgan Smith Co.
6	Generators	A.C.	Main units	1000		1,150			503		400				General Electric Co.
6	Governors	Hydraulic	Water turbines							D	330				Lombard Governor Co.
2	Turbines	Hydraulic	Exciter set												S. Morgan Smith Co.
2	Generators	D.C.	Exciters			125			600	H	550				General Electric Co.
1	Motor	Induction	Exciter			1,150	3	60	52	C.C.L.	530			100	Westinghouse Electric & Mfg. Co.
2	Governors	Hydraulic	Exciter turbine							B					Lombard Governor Co.
9	Switches	Oil break	Trans. lines							C.A.					General Electric Co.
5	Transformers	Oil cooled	Trans. lines	850		1,150		60							General Electric Co.
						33,000									

The Balanced Draft System of Furnace Regulation

This system of draft control is applied to boiler furnaces to so regulate the supply of air and exhaust of gases that a substantially uniform or atmospheric pressure is maintained in the furnace for all rates of combustion. By its use, the air supplied to the furnace can be regulated to just the proper amount required for the maintenance of the desired rate of combustion. It also is claimed to increase the capacity and the efficiency of both the furnace and the boiler, and permits the use of the cheaper fuels.

Other advantages claimed for it are increased life of the boiler and setting, and reduction in maintenance and repair expenditures, due to the elimination of strains caused by unequal expansion and contraction, and the disintegration of furnace linings which follows as a consequence.

Referring to Fig. 1, it will be seen that the ashpit is connected to an air duct leading to an engine-driven air blower. The position of the uptake flue damper is controlled by a regulator, as shown in Fig. 1, and illustrated in detail in Fig. 2. The regulator is belt driven from the fan engine, and the worm-shaft A, with the aid of suitable mechanism, oscillates the pawls FF backward and forward. The shield N, which oscillates with the pawls, prevents them from engaging with the ratchet wheels as long as the disk U oscillates with the shield, which it does normally.

The escapement is controlled by a Bourdon tube acting through the lever and the rod T. When the steam pressure is above normal, the left-hand side of the escapement is raised, engaging the disk U and preventing the shield N from moving to one side of its central position. The pawl on this side then engages the teeth of the ratchet wheel, turning it, and this motion is communicated by a worm gear to an operating lever which, through its connection, operates the damper in the corresponding direction.

The motion of the operating lever causes a compensator cam to turn, moving the outer end of the lever S in such a direction that the rod T is moved in a direction opposite to that which the Bourdon tube moved it. This regulator is said to be so sensitive that $\frac{1}{2}$-lb. variation

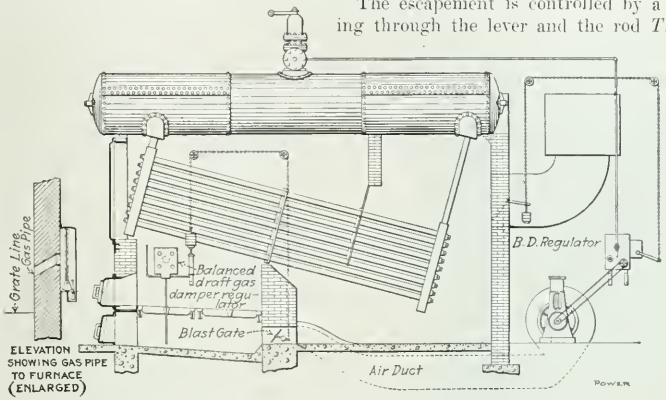


Fig. 1. Diagrammatic View of Controlling Apparatus

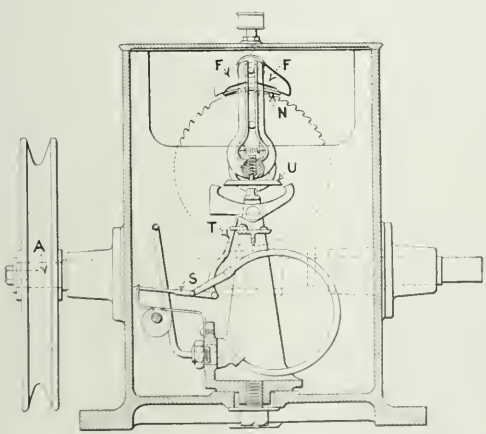


Fig. 2. Side and End Sectional View of B. D. Regulator

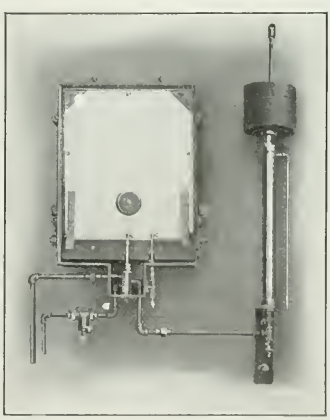


Fig. 3. Regulator Cover Removed

in steam pressure is all that is necessary to effectively operate it.

Figs. 3 and 4 show two views of the low-pressure regulator, which is operated by the pressure of gases in the furnace. It is connected to the furnace, above the grate by an opening in the back, as shown in Fig. 5. The front cover plate has four holes through which the atmosphere exerts its pressure against the outer surface of the regulator plate. This plate is made of heat-resisting material and is mounted on hardened-steel knife-edges; it is

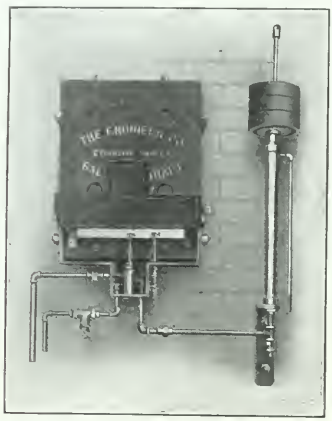


FIG. 4. REGULATOR COVER IN PLACE

weighted below the point of support. An adjustable weight is placed above the point of support, which when adjusted brings the center of gravity of the plate in the axis through the knife-edges. The plate then remains neutral in any position, and gravity will not have any tendency to turn it.

are practically frictionless, a difference in pressure between the furnace gases and the atmosphere of less than $\frac{1}{100}$-in. water gage is said to effectively operate this regulator.

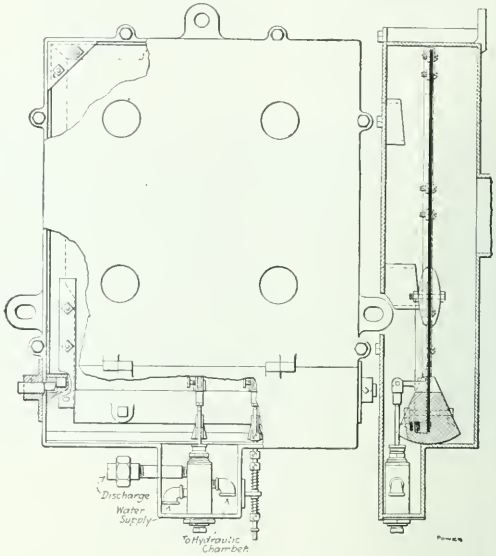


FIG. 5. DETAILS OF DAMPER

The action of the apparatus is as follows: Assuming that a steam pressure of 150 lb. is to be maintained, the B. D. regulator is so adjusted that the escapement is held in its neutral position when this pressure is exerted on the Bourdon tube. An increase of pressure beyond 150 lb. causes the mechanism to operate, moving the lever arm connected with the uptake damper, in the

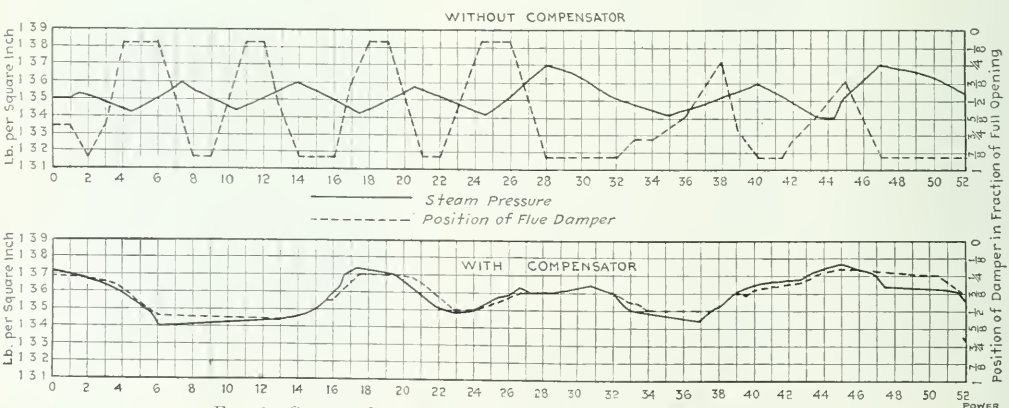


FIG. 6. CHARTS OBTAINED WITH AND WITHOUT COMPENSATOR

A small pilot valve, operated by the motion of the plate, admits water under pressure to an operating cylinder, the piston of which moves the blast-gate damper in the air duct, Fig. 1. As the gas pressure exerted on the face of the plate does not have to overcome any action of gravity on the plate, and as the knife-edge bearings

direction to close the damper. This causes an increase of pressure of the gases in the furnace, which actuates the regulator plate of the gas-damper controller, moving it outward and operating the pilot valve to admit water to the water cylinder, the piston movement of which causes the damper in the air duct to move toward its

closed position, which reduces the volume of air supplied to the ashpit.

The air damper continues to move toward its closed position, until the supply of air is so reduced that atmospheric pressure is again attained in the furnace. Thus a constant relation between the amount of opening of the air damper and that of the uptake flue damper is maintained. The rate of combustion is controlled by the B. D. regulator, and the draft is balanced by the gas-pressure regulator.

Due to the action of the compensator on the B. D. regulator, a very slight variation of steam pressure will cause a proportionately slight movement of the operating lever, and so long as the steam pressure remains constant at any point within the range of the regulator, the operating lever will remain stationary, in the position corresponding to the existing pressure.

In Fig. 6 are two sets of curves obtained with the B. D. regulator, without and with the compensator. The steam pressure is shown by the heavy line on the scale at the left. The position of the damper is shown by the dotted line, on the scale at the right. Both charts indicate that the total steam variation does not exceed 3 lb.

In the upper chart, the spaces inclosed by the dotted line above the steam line, reveal a condition where a rate of air supply exists in excess of that required for the average rate of combustion. The spaces inclosed by the dotted line below the steam-pressure line show a condition in which a deficient quantity of air is supplied. The average of these excesses and deficiencies gives the average rate of air supply which maintains the steam pressure uniform, but at a considerable loss in furnace efficiency. The ideal point of regulation is where the two lines representing the steam pressure and the damper movement coincide. The lower curve shows that this ideal is approached very closely when using the B. D. regulator.

The "Balanced Draft" system, as described above, treats a group of furnaces as one big furnace, regulating the total output from the group, but provides no automatic means for controlling each one of the group in reference to the others. Embury McLean, the inventor, has recently perfected a system of automatic control for a group of boiler furnaces whereby the output from each boiler will always maintain a fixed relation to the output of the group of boilers. This means that each boiler will be compelled by automatic means to do its *pro rata* share of the work. For very large plants, the same system of regulation can be applied in a different way to regulate the total output of the plant, by automatically cutting in or cutting out boilers, so that all of the boilers that are "in" are operating at their maximum capacity, which means maximum efficiency, and the boilers which are "out" are operated at combustion rate just sufficient to keep the boiler and setting hot to prevent condensation.

This new method of regulation the inventor considers as fundamental with reference to the regulation of each of a group of boilers, as his "Balanced Draft" system is in regard to the regulation of a single boiler, or a group of boilers treated as a unit.

All of Mr. McLean's United States patents covering furnace regulation are owned by The Engineer Co., 50 Church St., New York City.

Draft and Boiler Capacity and Efficiency

Tests in connection with the Blonck boiler-efficiency meter, described in the Dec. 24 issue, bring out some interesting points in the relation between draft, capacity and efficiency.

The problem in practical boiler operation is to secure capacity and efficiency simultaneously. It is well known that the CO_2 content is a reasonably good index to combustion efficiency but absolutely no guide to the capacity being developed. Hence, when CO_2 alone is depended upon, it is often found that when high CO_2 has been attained, the rate of steam output has fallen off and, to restore the proper rate quickly, it is necessary to sacrifice economy.

Most economical results are secured with a white fire and evenly covered grate, conditions conducive to high CO_2.

It is difficult for even a well experienced fireman to know simply by observation when these conditions prevail to a maximum extent. And even if good combustion conditions do prevail, it is especially difficult to be certain that the boiler is developing its proper portion of the load. The draft distribution, however, is a key to both efficiency and capacity.

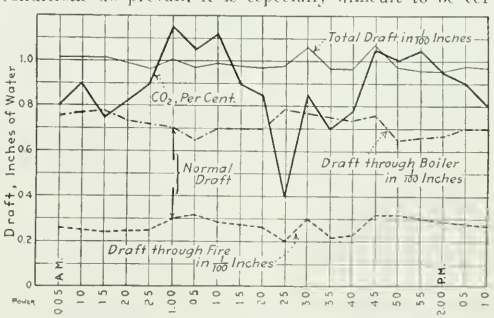


Fig. 1. Graphical Log of Test under Full Load of 375-hp. Stirling Boiler with Chain Grate

With the boiler operating at its normal rate (that is to say, with a fixed total effective draft) a decrease in the normal resistance of the fire produces an increase in the drop in draft through the boiler and a loss in efficiency due to excess air. An increase in the resistance of the fire causes a decrease in the drop through the boiler and a reduced rate of steaming; if the increase is extreme there is also an efficiency loss due to incomplete combustion.

These points are remarkably well illustrated in the accompanying figures when due consideration is given to the difficulty of synchronizing the draft readings and the CO_2 analyses and the probability of error in the analyses themselves.

In Fig. 1 the total draft remained practically constant from 10:05 to 11:25 o'clock, the greatest variation being but 0.05 in. The furnace draft, however, changed from 0.26 to 0.30 in. and the draft through the boiler from 0.76 to 0.71 in., producing a change in the CO_2 content from 8 to 11.5 per cent. Between 11 and 11:10 a.m. an apparent inconsistency exists as the furnace draft increases, the boiler draft decreases and the CO_2 falls

while logically it should rise. From 11:10 to 11:20 a.m. the total and boiler draft are constant and the furnace draft and CO_2 fall. Between 11:20 and 11:25 a.m. the furnace draft drops markedly, the boiler draft increases proportionately, and the CO_2 falls from 8.5 to 4 per cent., showing that the furnace was flooded with air. As the furnace draft rises from 0.23 at 11:40 to 0.32 per cent. at 11:45 o'clock the CO_2 increases from 7.8 not changed materially, the steam output was cut down as is clearly shown by the high furnace and low boiler draft.

Fig. 3 brings out the effect of the changes in total draft on the rate of steaming. The instantaneous flow-meter readings are erratic because the boiler was discharging to the same header with a number of other boilers and the feed regulation was adjusted largely by guess work.

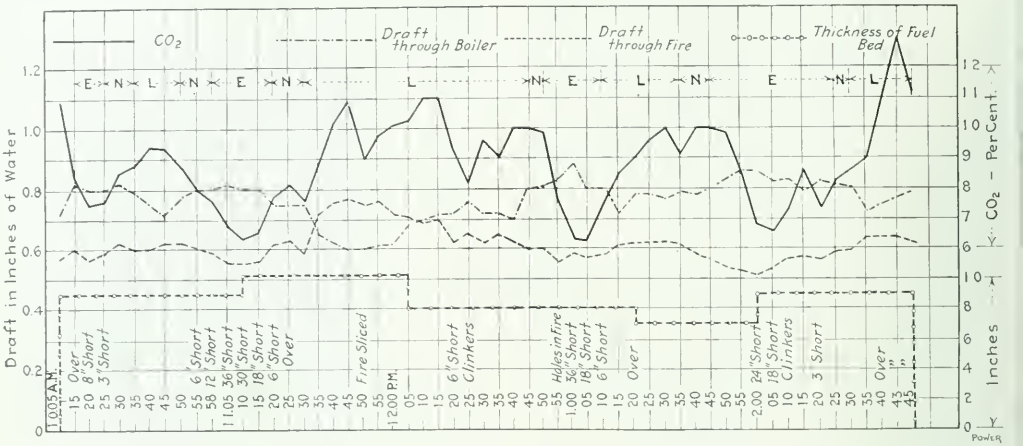


FIG. 2. GRAPHICAL LOG OF TEST OF 500-HP. BOILER WITH CHAIN GRATE, SHOWING EFFECT OF THICKNESS OF FUEL BED

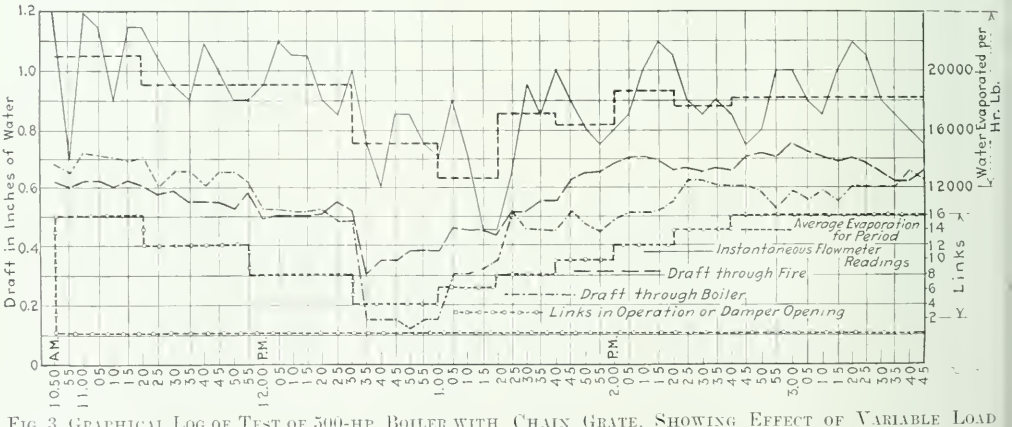


FIG. 3. GRAPHICAL LOG OF TEST OF 500-HP. BOILER WITH CHAIN GRATE, SHOWING EFFECT OF VARIABLE LOAD

to 10.5. At the same time, the boiler and total draft readings increase, indicating that output has increased simultaneously with the improvement in combustion efficiency.

The influence of the thickness of the fuel bed on the draft distribution, steam output and efficiency is brought out in Fig. 2. The effect of a "short" fire is also shown. At 11:05 and again at 1 and 2 o'clock the fire was 2 or more feet short, reducing the resistance of the fuel bed to the lowest point, increasing the draft through the boiler, due to excess air, and, hence, markedly reducing the CO_2 content. Between 11:10 and 12:05 o'clock the fuel bed was thickest and even and, because the total draft was

Nevertheless, it may be seen that the average evaporation for a given period follows quite closely the variations in draft.

It will also be noticed that when evaporating 21,000 lb. of water per hour between 10:05 and 10:20 a.m. the furnace draft was about 0.6 in. and the boiler draft about 10.7 in., whereas at the end of the test when an effort was made to bring back the rate to 21,000 lb. per hr., only the 18,000-lb. rate was attained because the fuel bed had become badly choked, thus increasing the furnace draft to over 0.7 in. and reducing the boiler draft to less than 0.6 and, hence, reducing the rate of combustion correspondingly.

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Dynamo and Motor Field Magnets

In most of the previous sections of the Primer, it has been assumed that the field magnet of a dynamo or motor has only two poles, and where illustrations were used they all showed the simple horseshoe type of magnet represented in Fig. 132, which was formerly the only type built. Except very small machines and some of special design to suit peculiar conditions, however, all modern dynamos and motors are made with more than two magnet poles; such machines are called "multipolar."

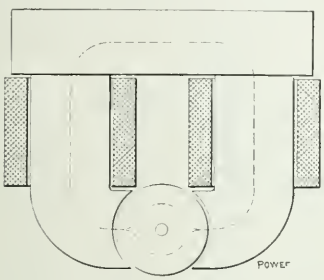


Fig. 132. Bipolar Field Magnet with Vertical Cores

If the reader remembers the discussion of the electromagnet in one of the early installments of this series, he will doubtless wonder how one magnet can have more than two poles. It cannot; but two or more magnets can be combined in one structure, with the result that there are four, six, eight or some other even number of poles, and that is what is done.

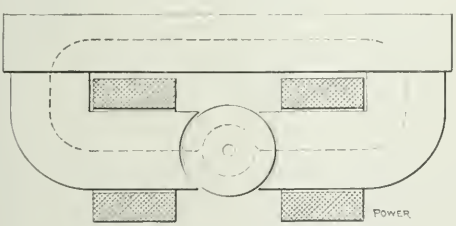


Fig. 133. Bipolar Field Magnet with Horizontal Cores

Figs. 133 to 136 inclusive illustrate the development of the modern four-pole magnet frame from the original "horseshoe" type of Fig. 132. The only difference between Fig. 132 and Fig. 133 is that the parts of the magnet which are surrounded by the coils are vertical in the one and horizontal in the other. The parts surrounded by coils are the "cores" of the magnet. Retaining the horizontal cores of Fig. 133 and dividing the connecting yoke into two parts, one above and the other below the armature, produces the type shown in Fig. 134. In all three diagrams the center of the path of the magnetic flux, or lines of force, is indicated by the dotted lines.

It will be noticed that in all cases the flux divides into two paths through the armature core, one-half going on each side of the shaft hole. In Fig. 134 it does the same thing in the yoke, and as each branch of the yoke carries only one-half of the total flux the cross-section is one-half as large in this form as in the simpler forms shown in Figs. 132 and 133.

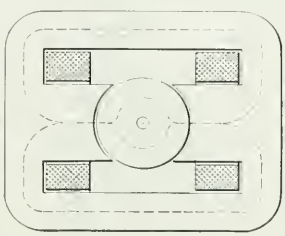


Fig. 134. Bipolar Magnet with Divided Yoke

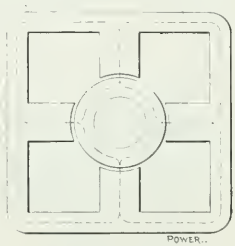


Fig. 135. Four-pole Development from Fig. 134

The next step is from the bipolar form of Fig. 134 to the four-pole form of Fig. 135. This is made by simply adding two poles and cores midway between the first two and making the outer frame (yoke) square instead of oblong to provide space for the lengths of the added cores. It will be noticed that the four-pole yoke and each magnet core are much thinner than those of the bipolar machine; this is also true of the armature core. The reduction in the thickness of the magnet cores does not result in a corresponding reduction in total weight because there are twice as many thin cores. But the reduction in the thickness of the yoke and that of the armature core effects a reduction in weight that is almost proportional, and this is one of the principal advantages of multipolar construction.

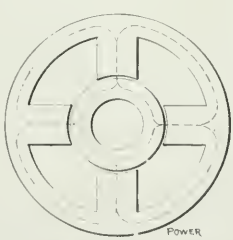


Fig. 136. Modern Type with Circular Yoke

Relation between Number of Poles and Cross-section

A little reasoning will make it clear why reduction of the thickness of the cores and yoke is made possible by increasing the number of poles. Suppose that the total magnetic flux through each magnet core of the two-pole machine in Fig. 134 were 1,200,000 lines of force and the magnetic density were 80,000 lines per square inch in the yoke, the magnet cores and the armature core. As the flux splits into two parts in the yoke, 600,000 lines pass each way from pole to pole; therefore the cross-section of the yoke must be 7½ sq.in. In each magnet core the cross-section must be 15 sq.in. and the armature core must have 7½ sq.in. of cross-section to carry 600,000 lines (one-half of the total flux) at the density assumed. (It is not customary to make the magnetic density the same in all parts of the circuit; that is done here for simplicity.)

Now consider the four-pole machine. With a total flux of 1,200,000 lines there will be 600,000 lines crossing each *pair* of air gaps and passing through each *pair* of

Fig. 137. Six-pole Equivalent of Fig. 136

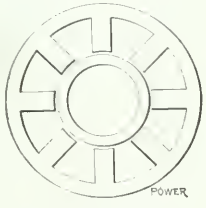


Fig. 138. Eight-pole Equivalent of Fig. 136

magnet cores. This flux of 600,000 lines per pole divides into two fluxes of 300,000 lines each in the yoke and in the armature core. In the two-pole machine the flux in the yoke and armature paths was 600,000; here it is 300,000; therefore the yoke cross-section can be made $3\frac{3}{4}$ sq.in. instead of 7½, and the armature section also reduced one-half. The magnet cores carry 600,000 lines each instead of 1,200,000 and the cross-section therefore may be made 7½ sq.in. each, instead of 15. It will be found that Fig. 135 and all the succeeding diagrams are so proportioned as to make the thicknesses of the cores and yoke correspond to the figures just given.

Four-pole machines are not usually built with yokes of square outline as in Fig. 135; this form is shown here to make the step from two-pole to four-pole construction as simple as possible. In general, the yoke is made of circular form, as in Fig. 136.

The same reasoning as to the relation between the number of poles and the cross-section of each magnetic path in a machine applies to dynamos and motors having more than four poles. For the same output, speed and magnetic densities, the cross-sections of a six-pole machine are one-third those of a bipolar machine (or two-thirds those of a four-pole machine) and the cross-sections of an eight-pole magnet and armature are one-fourth those of a bipolar, one-half those of a four-pole, or three-fourths those of a six-pole machine. Figs. 137 and 138 are to the same scale as the preceding diagrams and with them furnish an accurate comparison of the sizes of magnet frames and armature cores with different numbers of poles.

In all cases here represented, the differences in cross-section have been put into the thickness of each part to make them visible. For example, the thickness of the yoke in Fig. 135 is made one-half that in Fig. 134 to indicate a cross-section one-half as great. In actual machines this is not customary; the greater the number of poles, the shorter is the machine, measured along the shaft, and there are not as great differences in the radial thickness of the yoke and armature core and the transverse thickness of the magnet cores as are here shown.

In view of the great reduction in the cross-sections and therefore the weights of machines due to increasing the number of field-magnet poles it would seem desirable to make all dynamos and motors with a large number of poles, to save material. There are other things to be considered besides weight, however, and most of these make either the bipolar or the four-pole form preferable to a large number of poles. Only when lightness is the most important consideration, or when good commutation or convenience in handling the armature winding make it necessary, are more than four poles used. In general, large machines are built with six or eight poles because of one or both of the points last mentioned.

Distribution of Magnetizing Forces

The magnetic relations between the different cores of a multipolar machine are a little hard to understand at first. Probably the easiest way of considering them is

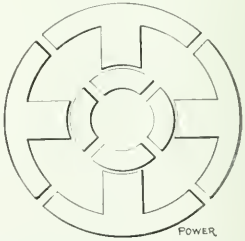


Fig. 139. Distribution of Magnetizing Forces

to say that each magnet coil supplies flux through the core it surrounds and the corresponding airgap, the yoke halfway between that core and the next one on each side of it, and the same relative part of the armature core. For example, in a four-pole machine, imagine the frame and armature cut into four equal parts, as in Fig. 139, and each part magnetized by the coil included with that part.

Another view is that each pair of poles constitutes one magnet and that the several magnets are connected by their yokes and share the connecting paths equally. This is not as logical a view as the first one because the flux in any one core actually divides between the two cores on each side of it, so that the whole system of cores is "tied together" magnetically as well as mechanically.

GAS POWER DEPARTMENT

Classification of Oil Engines

By Oscar P. Ostergren

The present development of the oil industry is due, first, to the art of drilling wells, which has made it possible to reach successfully and economically depths of from 4000 to 5000 ft., and second, to a better knowledge of geological conditions of oil-bearing strata.

In 1908 the U. S. Geological Survey reported 8450 square miles of oil territory in the United States alone, leaving an estimated possible future production of from 10,000,000,000 to 24,500,000,000 bbl. These figures refer only to the practically proven oil territory in the United States and may be considered conservative. Outside of this it is, of course, impossible to say what the actual production will be.

Crude petroleum consists principally of various combinations of hydrogen and carbon with comparatively small amounts of nitrogen, oxygen and sulphur. Nitrogen and oxygen and any incombustible residue of ash may be classified as inert impurities. Sulphur, though combustible, has a low heat value and is otherwise injurious. Taking hydrogen and carbon as the principal constituents, it is found that those oils which are rich in the former element are of light specific gravity as compared with those rich in carbon.

The range in specific gravity of California crude oil may be taken as from 0.84 to 1 or from 10 to 36 deg. Bé. It is evident that, other things being equal, oils rich in hydrogen will contain more heat units per pound than those rich in carbon, pure hydrogen having a heat value of 62,000 B.t.u. per lb. as compared with 14,650 B.t.u. per lb. of carbon.

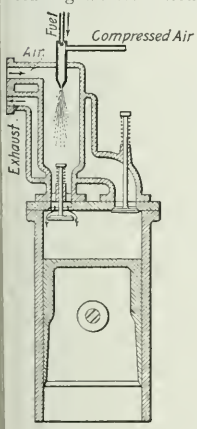


FIG. 1

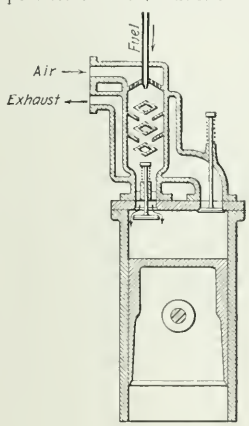


FIG. 2

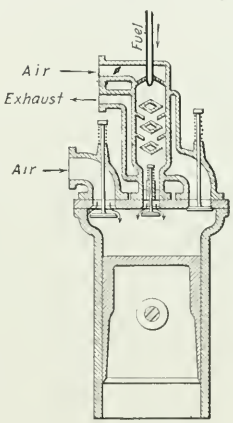


FIG. 3

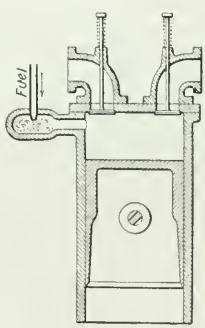


FIG. 4

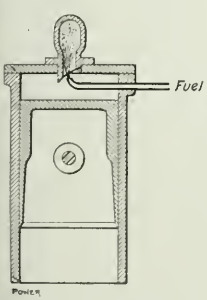


FIG. 5

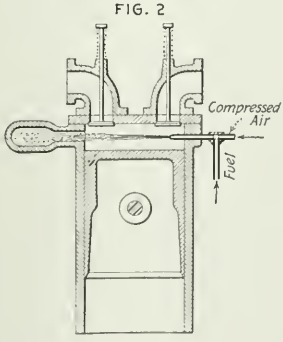


FIG. 6

Typical Vaporizing and Mixing Arrangements

The extended use of the gasoline engine has indirectly given a great impetus to the oil industry and incidentally to the manufacture of heavy oil engines. The problem of utilizing heavy hydrocarbons, such as kerosene and fuel oil or even crude oil, so as to produce an explosive mixture has been such a difficult task that for many years no effective engine of this class was placed on the market.

Through numerous experiments it was seen that to get a proper mixture the oil must first be vaporized by the aid of high temperatures. Indeed, the problem resolved into a gradual and simultaneous heating of both fuel and air, gradually adding more air to the mixture up to the time of explosion. Upon the ability to carry out this process or approximate it in an engine, hinged the success of the latter, and many have been the failures of otherwise meritorious inventions because the requirements for the foregoing process had not been observed. Thus, the vaporizer must not be too hot, as that would cause decomposition of the fuel and deposits of carbon; nor must the mixture be allowed to cool down, as that would cause precipitation of oil in the passages, valves and cylinder, likewise causing deposits of carbon.

The problem of suiting the mixture to the load was

also important. Typical arrangements that have been tried for vaporizing and mixing are shown in Figs. 1 to 6. In Fig. 1 the liquid fuel is mixed with and broken up by an air jet under 10 to 25 lb. pressure, entering the vaporizing chamber in a finely divided spray. The bulk of air mixes during the suction stroke with the preheated air and vaporized fuel as it is drawn through the vaporizer and enters the cylinder where it is compressed and ignited the same as in a gas or gasoline engine.

It will be noticed that this vaporizer must be heated at first with a torch, or the engine must be started with some lighter oil, such as gasoline. After starting, the heat of the exhaust gases will be sufficient to keep the vaporizer hot.

Figs. 2 and 3 represent vaporizers commonly used in connection with ordinary gas or gasoline engines for the utilization of heavy oils. Fuel vapors are produced by precipitating the liquid fuel on a series of baffles inside the vaporizer. In Fig. 2 the vapors are absorbed by the entire air current which traverses the vaporizer during the suction stroke, while in Fig. 3 only a part of the air is allowed to pass through the vaporizer, the bulk of the air being admitted to the cylinder by an independent valve.

The principle represented in Figs. 4 and 5 is extremely simple. In Fig. 4 the fuel is injected into the vaporizing chamber, which for starting has been heated to incandescence by a torch; after the engine has been started the vaporizer is maintained incandescent by the heat of combustion and compression. During compression air enters at high speed through the contracted opening and mixes with the vapors therein contained until at the end of the stroke the mixture attains the proper proportion and temperature for explosion. The sides of the chamber must be hot enough to ignite the charge, but not hot enough to decompose the fuel.

In Fig. 5 the method of introducing the fuel is somewhat modified. The oil is forced in by means of a governor-controlled force pump through a very small orifice. In the form of a fine spray it impinges on a baffle or extension of the bulb and a part of the fuel is deflected into the latter or a suitable pocket. By this arrangement it is quite feasible to vary the amount of the fuel charge within a considerable range.

In Fig. 6 the fuel is injected right into the cylinder by means of a high-pressure air jet. This jet is so directed that a considerable part of the fuel vapor will enter a hot chamber or sometimes impinges on a hot plate. In this case the fuel admission is timed and begins a few degrees before the piston is at the end of the compression stroke. By this arrangement the danger of premature ignition is entirely removed. Not only is it possible to carry the compression much higher than in the former cases, but inasmuch as the fuel is gradually consumed as it enters the highly compressed air the thermal cycle is greatly improved for all conditions of load. This type of engine might be considered as a link between the types formerly described and the Diesel.

With the exception of the last type those mentioned are not as efficient thermally as a gas engine. The difficulties which prevent any extended improvement are to be found in their method of vaporization. In each case, it will be seen the air has to be preheated to a certain extent. This is poor practice: first, because preheating decreases the charge in weight and also the capacity of the engine, second, the range of compression is limited on account of the danger of premature ignition due to additional compression temperature. The necessity of heating the vaporizer before starting or having to start the engine on gasoline is also a drawback.

Case 6 is superior to the others in all respects, except that it is more complicated and employs preheating. The range and nicety of governing is also greatly limited in cases 1 to 5 by the fact that at light loads the mixture when weakened to a certain extent abruptly ceases to explode, no matter to what temperature it is subjected. The average fuel consumption in cases 1 to 5 is about 1 lb. per b.hp.-hr., corresponding to about 15 per cent. thermal efficiency. Attempts have been made to attain high compression pressures by lowering the temperature thereof by the injection of water during the compression period. In this way it has been proved that the compression can be carried considerably higher, and in some engines this principle is employed where hot bulb vaporizers are used.

The Diesel Group

While the principle of the Diesel engine is quite simple and has from time to time been discussed in these columns, it will only be necessary for the present purpose to give a brief outline of the scheme which is at the base of the world-wide activity now manifest since the expiration of the original Diesel patents.

This engine has the following characteristics of operation: During the compression stroke the cylinder contains only air, which is compressed to at least 450 lb., the resulting temperature reaching a point sufficiently high to ignite the liquid fuel injected (at least 1000 deg. F.). At the end of the compression stroke fuel is gradually injected by means of an air blast at a pressure about 250 lb. above that in the cylinder. This high-pressure air blast completely atomizes the fuel during the injection periods and carries its minute particles directly into the air in the cylinder, compressed and heated as mentioned, wherein they are immediately vaporized and ignited.

The progress of the fuel injection is so adjusted that combustion takes place without any material explosion or rise in pressure and is continued for about 10 per cent. of the expansion stroke, causing the development of heat to take place at approximately constant pressure for the admission period. Since the proper condition for ignition and combustion exists throughout the air body, the oil particles burn immediately after penetrating the first products of combustion and reach the fresh oxygen of which there is a large surplus, even for the maximum charge of fuel: there is no possibility of the fuel reaching the enveloping surfaces without being consumed. For this reason there is no opportunity for carbon deposits to form on the cylinder walls, and the combustion is so complete that the exhaust products are smokeless and without odor.

The average fuel consumption for the Diesel engine is less than ½ lb. per b.hp.-hr., corresponding to a thermal efficiency of about 30 per cent. or more. To this high fuel economy the Diesel engine largely owes its success in Europe, but there are also other contributing reasons.

As the compression of the air free from fuel can be carried to a pressure corresponding to an incandescent temperature, most any liquid fuel can be utilized without other accessories than the auxiliary air compressor, which furnishes the injection air, the injection and spraying apparatus, and the fuel pump. This, of course, does not

include the circulating pump for the jacket water, which is also necessary in the other types.

The Diesel engine is well adapted to work on the two-stroke cycle as the scavenging process is accomplished with air alone, a surplus of which may be used to insure a clean cylinder. No waste of fuel can take place in this connection and no backfiring.

Fig. 7 represents the position when a measured quantity of fuel, according to the load, is being deposited in space *S* of the injection-valve cage *C* by the oil pump *O*, the injection valve *N* being closed. Space *S* is continuously in communication with the air storage tank *T* into which the two-stage air compressor *A* delivers the air required for fuel injection at a pressure of from 750 to 1000 lb. The oil must, therefore, be delivered into space *S* against this high pressure, which in view of the small quantity to be delivered, requires extremely accurate work and adjustment on the oil pumps. Since the fuel and injection air come in contact while the injection valve *N* is still closed, it is obvious that the valve cage *C*, as well as the injection air, must be well cooled to prevent dangerous premature ignitions or the formation of deposits due to partial evaporation of the deposited fuel.

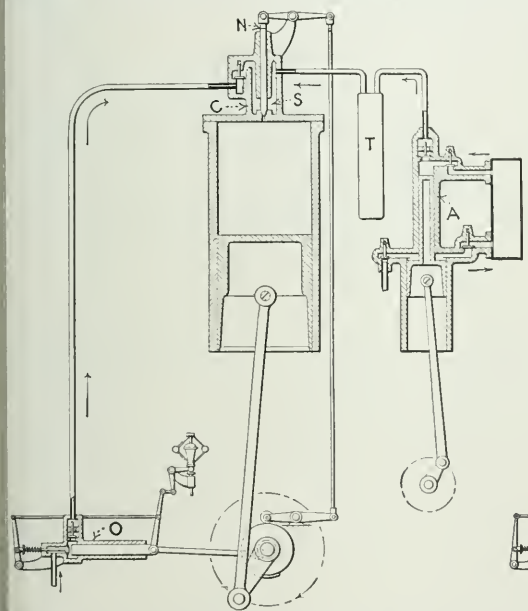


Fig. 7. Position When Fuel is Being Injected into Valve Chamber

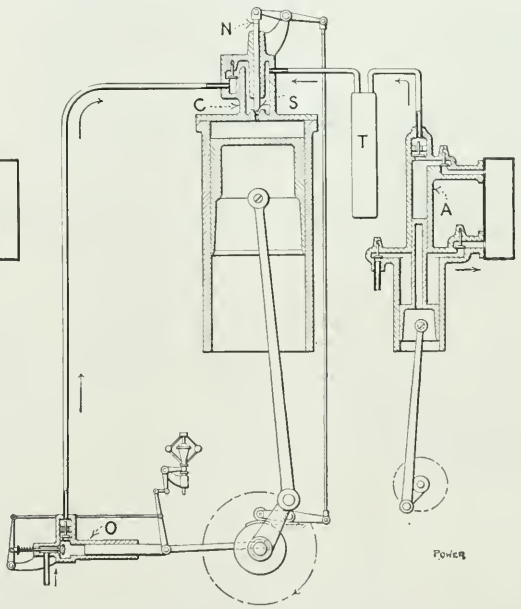


Fig. 8. Position When Fuel is Being Injected into Cylinder

Fig. 8 represents the actual injection period which starts as soon as valve *N* opens; the latter, therefore, controls simultaneously the admission of fuel and injection of air into the cylinder. At all loads the time of opening and closing of the injection valve *N* remains unchanged, that is, the period the injection valve is open is constant. Within this period a variable quantity of fuel, according to the load, is injected.

To accomplish this most satisfactorily it has been found necessary to increase the pressure of the injection air with increasing loads on the engine, that is, with increasing amounts of fuel to be injected. Diesel-engine manufacturers recommend a pressure increase of about 250 lb. from light to maximum load. Since the compression in the engine cylinder is constant at all loads, this is undoubtedly due to the fact that there must be sufficient pressure to accelerate the largest charge of oil, so that it is properly atomized, on the one hand, and not enough to extinguish the ignition from the cooling effect when small charges are injected, on the other.

Summarizing, the essential features of the Diesel engine are: The air is compressed while unmixed with fuel, which permits high compression and economy of fuel. Ignition takes place at the proper time without fail and without special devices. It can operate economically within a wide range of loads and is well adapted for the two-stroke cycle. It can operate with a great variety of hydrocarbons.

In accordance with the purpose of this article the present limitations of the engine should also be set forth. It requires a high degree of workmanship in manufacture and the first cost is high in comparison with other prime movers. It is heavier per horsepower than most types of internal-combustion engines and on this account is unsuited for special purposes such as for vehicles. The features of variable pressure for the injection air adds complications to the engine or watchfulness on the part of the operator. It requires the storage of air at high pressure for starting (about 1000 lb.) and, as a whole, is very complicated. The power of one cylinder is strictly limited. All these objectionable features are strictly true, notwithstanding claims to the contrary by manufacturers and enthusiasts. But experimental work is being carried on continually and it is the writer's opinion that each of these limitations will be and are being eliminated.

REFRIGERATION DEPARTMENT

Weighing Ammonia to Determine Refrigerating Capacity

By Fred Ophüls

When testing boilers it is customary to weigh or measure both the water and the fuel fed to them during the test. The weight of water divided by the weight of the fuel used for a certain time gives the actual weight of water evaporated per pound of fuel fired, proper corrections being made for moisture in the steam, etc. It is not customary in this case to condense the steam produced by the boilers after it has passed through engines, pumps, heaters, and the machinery and apparatus and then weigh the condensate, also determine the heat carried away through the stack from the composition, weight and temperature of flue gases, add to this the heat supplied to the water to turn it into steam and allow for radiation and other heat losses, and by dividing the total quantity of heat so obtained by the heat value of the fuel per pound, determine the weight of fuel used.

For testing the performance of refrigerating machinery the method is somewhat comparable to the latter method of

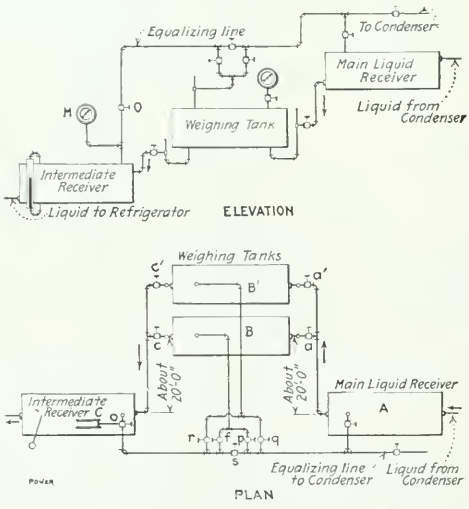


Fig. 1. Piping Connections for Weighing System

finding boiler economy. It is based on measuring or weighing the amount of brine cooled and the range through which it is cooled. Any errors in observing the temperatures and quantities and the losses unaccounted for will effect the accuracy of the result.

Take, for example, a case where 120 gal. of brine is circulated per minute and the temperature range of the brine is 6 deg. F., which is equivalent to 25 tons of refrigerating effect. An error of one-tenth of a degree in each of the brine readings may cause the range to be either two-tenths of one degree too high or too low. The error in that case would be 2 in 60, or about 3⅓ per cent. Increasing the number of gallons of brine circulated to 240, the brine range for the same tonnage would be only 3 deg. F. and for the same error of reading the result would be either 7 per cent. too high or too low. Further errors are introduced into the calculations by discrepancies in the brine reading itself and fluctuations in operating conditions during the intervals between readings.

Many attempts have been made to weigh the liquid anhydrous ammonia, and in this way get an accurate knowledge of the exact amount of the actual refrigerat-

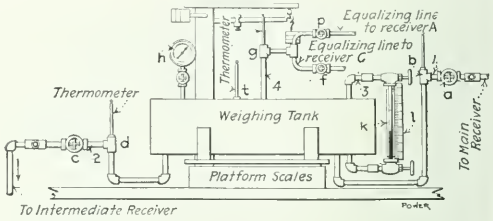


Fig. 2. Detail Sketch of Weighing Tank

ing medium circulated in a given time. The weight of ammonia circulated can be obtained with great accuracy if due care is taken in the installation and handling of the weighing apparatus.

Liquid anhydrous ammonia cannot be so easily handled as water or other liquids. It must be maintained under a high pressure when it is being weighed and before it enters the refrigerator, which makes the problem somewhat difficult. It is necessary that the tanks in which the liquid is stored and those in which it is weighed be joined by supply and discharge piping and by pressure equalizing lines to permit the flow of the liquid from one to the other.

It has been claimed that the equalizing lines especially are a source of error. It will be shown here that this error is small, if it exists at all, and that it can be minimized by a proper manipulation of the weighing outfit.

In Fig. 1 is shown a proposed arrangement of the ammonia receivers and the weighing tanks. For facilitating the flow of liquid from one tank to the other, the weighing tanks are placed lower than the main receiver and the intermediate receiver below the former. It may be noticed that the equalizing line is provided with the necessary valves so that each tank can be shut off from the line completely, or either one, two, three, or all four tanks equalized at one time.

Fig. 2 shows in detail the proposed arrangement of the piping, valves and instruments around the weighing tanks. It may be seen that the liquid ammonia enters the weighing tanks through pipe 1 at the right-hand end. This pipe connection is supplied with a shut-off valve *a* and a mercury well *b* with thermometer. The liquid leaves

the tanks through pipe 2, which is provided with a valve c and a mercury well d with thermometer. The equalizing pipe 4 has valves f and p and a mercury well with thermometer at g. A high-pressure ammonia gage h serves to show any undue fluctuations in pressure in the tank and the gage-glass k, to show the height of the liquid in the tank, this being read off in inches on scale l.

The intermediate receiver is also provided with a gage-glass, pressure gage and a mercury well with thermometer in the pipe leading to the expansion valves.

When the plant is adjusted and conditions are as desired for the test, close the valves c and c', Fig. 1, and allow the weighing tanks to fill, keeping the equalizing valves all open. When the weighing tanks are filled to the desired height, close off tank B entirely by shutting the valves a, f, p and c. Open the valve c' on tank B' so that the ammonia it contains can run into the lower tank C and feed the system while tank B is being weighed. The valve c' on tank B' is so manipulated that the liquid level in tank C is maintained at a fixed point marked on its gage-glass.

When tank B has been weighed, pressure gage h read and the temperatures at b and d and of the air surrounding the tank have been taken, shut valve c' on tank B' exactly on the time of taking the first reading. Close the equalizing valves r and s, so that tank B' equalizes into the line to tank A only. In case any undue pressure has accumulated in tank B, let it equalize to tank A by opening valve p for a moment and weigh it again. Then equalize tank B over to tank C and by opening valves f and o allow all the liquid you wish to take from tank B to drain as quickly as possible into tank C. Shut off tank B from the system and weigh. The difference in weight will give the pounds of ammonia discharged into tank C, after making an allowance for greater quantity of vapor in tank B, when empty than when full. The volume and weight of this vapor can be determined by calibrating the weighing tanks with ice-machine oil before connecting them into the system and by noting the temperature and pressure in the tank when testing. Each weighing tank should have a mercury well t with thermometer for this purpose.

The pipe connection 2 from tanks B and B' to tank C should be made of ample size so that the liquid in the weighing tanks can flow rapidly into tank C; in this way there is a perfect balance between the vapors above the liquid level in each tank.

Tank B' having been filled, closed off from the system and weighed while the liquid was flowing from tank B into tank C it is ready, when tank C has been emptied to the desired point, to supply the latter with fresh liquid. To avoid a pressure drop in tank C while it is emptying, it is again equalized with tank B while the latter is being refilled.

It may be noticed that the liquid inlets are at the bottom of the weighing tanks. This precaution is taken so that no exchange of vapor can occur between them, the receiver A and the ammonia condensers. The equalizing connections from the tanks B, B' and C to tank A and the condensers are only used at the start of the test and whenever it is desired to change the pressure in these lower tanks.

By filling tank B at the same rate as tank C is emptying, the same pressure is maintained on the liquid while feeding into the refrigerator, which is desirable for good test results. As soon as tank C is empty it is completely shut off from tank B, and the liquid in tank B' is drained into C and the same manipulation gone through with as before described for tank B.

With the tanks arranged as shown in Figs. 1 and 2, and allowances made for the change in the amount of vapor in the weighing tanks when full and when empty the weights obtained should be correct. The temperatures of the liquid while entering and leaving tanks B, B' and C should be carefully observed so that any correction necessary on account of the heat leakage may be made. The heating surfaces are small as well as the temperature differences between the room and the liquid in the tanks.

A more difficult point to take care of is the quantity of liquid in the expansion side of the plant. This should be the same at the end of the test as it was at the beginning, so that the amount of ammonia weighed corresponds with the amount of ammonia actually evaporated. While the amount of ammonia in tank C can easily be brought to the proper level at the end of the test by judicious feeding from the weighing tanks and observing the liquid level, there is no practical arrangement that can be made in a refrigerating plant of any size by which the quantity of liquid ammonia can be observed in the low-pressure side either by weight or by sight glass, except in the case of a shell type or a straight-tube brine cooler. No gage glasses can be attached to double-pipe brine coolers or direct-expansion piping in the cold-storage rooms or cellars which will show the amount of liquid in the coils at any time during the test. It is, however, safe to say that when in a brine system the back-pressure temperature of the vapor at the compressor, the revolutions of the compressor, the initial and final brine temperatures and the quantity of brine being pumped through the system are all about the same at the end as at the beginning of the test, the quantity of liquid ammonia it contains

AMMONIA CIRCULATED PER MINUTE AS DETERMINED FROM BRINE WEIGHT AND TEMPERATURE RANGE AND BY WEIGHING

	Test number	1	2	3	4	5	6	7	8	9	10	11
1	B.t.u. removed from brine per min.	10,044	10,466	10,410	8028	12,192	14,410	10,298	10,252	10,640	7710	12,782
2	Abs. suc. press., lb. per sq.in.	35.23	35.35	35.73	35.46	35.51	34.51	35.43	35.14	35.00	35.41	35 21
3	Temp. of saturated vapor, deg. F.	6.68	6.82	7 28	6.96	7.01	5 66	6 93	6.58	6.40	6.90	6 65
4	Suction temp. at cooler	21.11	19 55	15.62	19.40	11.58	14.69	9 33	9.36	10.37	9.29	9 90
5	Vapor superheat	14 43	12 73	8.34	12.44	4.57	9.03	2.40	2.78	3 97	2 39	3 25
6	Liquid temp.	76.47	65 80	71.05	58.91	70.55	70.40	74 85	74.16	71 98	77 91	76 61
7	Liquid superheat	69.79	58 98	63.77	51.95	63.54	64.74	67.92	67.58	65.58	71.01	69 96
8	Heat of liquid	76.77	64.88	70.15	57.15	69 89	71 21	74 71	74 34	72 14	78 11	76 96
9	Latent heat at cooler pressure, B.t.u.	564 88	564.77	564 42	564 68	564 63	565.55	564 70	564 96	565.09	564 72	564 90
10	Available latent heat, B.t.u.	488 11	499 89	494 27	507.53	494 74	494.34	489 99	490 62	492 95	486.61	487.94
11	Heat of vapor, B.t.u	7 33	6 47	4 24	6.32	2.32	4.59	1.22	1.41	2 02	1 23	1 65
12	Available B.t.u. per lb.	495.44	506 36	498.51	513.85	497.06	498.93	491.21	492 03	494.97	487 82	489 59
13	Lb. of ammonia circulated per min. from brine	20 26	20 62	20 86	15.62	24 50	28 88	20.94	20.81	21.52	15.81	26 10
14	Lb. of ammonia circulated per min. by weighing	19 01	20 00	20.20	15.78	24.80	29 87	20 76	20.43	21.04	15.6	26 00
15	Ammonia by weighing ÷ ammonia from brine, per cent	93 7	97 0	96 8	100.8	101 1	103.3	98.8	98 2	97 8	98 6	99 6

is the same in either case. When a direct-expansion plant of a cold-storage house or ice-making system is being tested similar precautions must be taken.

That the above apparatus or one similarly arranged will give exact results is demonstrated by the figures in the accompanying table. The figures of capacity given in line 1 for the eleven tests made were carefully determined and are as accurate as can be obtained when all instruments used are calibrated before and after the tests. It is the writer's opinion that the more accurate the tables of the properties of anhydrous ammonia become, the more closely will the weight of ammonia as found by actual weighing agree with the weight obtained by calculations from the heat removed in the refrigerator. The calculations given here are based on the figures in the table of the properties of anhydrous ammonia published by H. J. Macintire in the *Cold Storage and Ice Trade Journal*, August, 1912. This table while lacking confirmation as a whole, was carefully checked by the writer for ranges of pressure commonly used in connection with refrigerating plants and was found to be more accurate than the old one compiled by Wood & Davidson.

The second line in the table gives the absolute ammonia suction pressure in pounds per square inch and in the third line the corresponding temperatures of the saturated vapor in degrees Fahrenheit. The suction temperature at the cooler in line 4 shows the quality of the vapor leaving it, and it may be noticed that in all cases the suction vapor was slightly superheated. It is necessary when testing the capacity of a refrigerating plant by weighing the liquid ammonia fed into the refrigerator to so operate the latter that the ammonia vapor leaving it will be slightly superheated. This precaution must be observed to prevent liquid ammonia from leaving the refrigerator with the vapor flowing to the compressor. When the thermometer in the suction pipe to the compressor indicates that the vapor is at the temperature of saturation, the amount of liquid, if any, that it may contain cannot be determined from the temperature as the latter stays at the saturation point for any quantity of liquid present in the vapor. In the event that liquid is contained in the vapor a capacity calculation based on the pounds of ammonia fed into the refrigerator would be too high by the per cent. of liquid present to the total amount weighed.

A correction for wet vapor leaving the refrigerator can be made, but this article will deal only with the simple case where the vapor leaving the refrigerator is slightly superheated, which, by the way, is the most economical point at which a refrigerating system can be operated.

The vapor superheat and heat of vapor are found in lines 5 and 11, while in lines 6, 7, 8 and 9 the various steps to arrive at the available latent heat per pound of refrigerating medium circulated are recorded and finally in line 12 the heat absorbed by the liquid in the refrigerator for each pound evaporated is given. Dividing the values in line 12 into the heat removed from the brine in line 1 gives the weight of ammonia circulated per minute, as found from calculations based on the heat removed from the brine.

In line 14 is recorded the actual weight of liquid ammonia used per minute as determined by means of a weighing apparatus somewhat similar to the one described. In line 15 will be found the percentages that the ammonia found by weighing is more or less respectively than that determined from brine cooled. The average percentage of all the tests is 98.7 and for the ten last tests 99.2. All the results obtained by weighing, except the first one, are well within the limits of error of such experiments. The conclusion is even justified that the actual values of the pounds of ammonia circulated as found by weighing are more correct than the others. It must be remembered that by determining the actual amount of ammonia circulated by weighing, a complete record of the work done is obtained, while by recording brine readings every 10 or 15 min. any fluctuations of capacity between readings are lost sight of.

Heretofore it was deemed impossible to make accurate tests of the performance of refrigerating plants of the direct-expansion type. There does not seem to be any good reason, now that the properties of anhydrous ammonia are better known, why tests with weighing tanks should not be made and considered as, if not more, accurate than tests based on brine-cooling capacity. These tests, however, must be of sufficient length so that any error that might arise, due to the expansion side of the plant containing more or less ammonia at the end than it did at the beginning of the test, is negligible.

The actual refrigerating capacity required to make ice under varying outside temperatures, distilled water and condenser water temperatures has never been accurately determined. Allowances have always been made for radiation and other losses not directly measurable with the thermometer or with other instruments, which left the correctness of the final result very much in doubt. The question of whether or not more refrigeration is required to make can ice or plate ice, or as a matter of fact any quality of ice, can be and should be definitely settled. The most refined calculations will not equal in value a good test made with weighing tanks properly handled.

Refrigerating Plants Installed in 1912*

New ice-making plants—under which is included additions to existing plants and the more important ice-making systems installed in connection with refrigerating plants, as at packing houses, breweries, etc.—were installed to the number of 389, as compared with 433 such installations reported in 1911.

Cold-storage houses to the number of 66 were reported (this number not including several large houses now in process of construction), as compared with 52 such warehouses, reported in 1911. The total amount of cold-storage space added during 1912, while largely a matter of estimate, is figured at over 10,000,000 cu.ft.

	Number	Tons Refr.
New ice making plants	389	17,178
Cold storage warehouses	66	3,119
Breweries	47	4,552
Packing houses	35	3,494
Provision houses	36	684
Meat markets	175	881
Creameries and dairies	169	1,948
Ice cream factories	60	1,203
Hotels	60	833
Restaurants	23	101
Produce commission houses	41	458
Oil refineries	12	924
General stores	35	243
Grocery stores	23	185
Confectioners	20	413
Hospitals and asylums	37	337
Fish freezing and storage	13	180
Office building	27	368
Schools and colleges	10	97
Residences and apartments	15	40
Miscellaneous	101	2,571
Total	1394	39,809

*From "Ice and Refrigeration," Chicago.

EDITORIALS

Engineering and the Co-operative School

At present the whole country is particularly interested in our public schools, and especially in the new coöperative high schools. The coöperative high-school courses are conducted much as are the courses in engineering advocated and practiced by Dean Schneider, of the University of Cincinnati.

In these coöperative schools the students work alternately in the classroom and the work shops of near-by establishments. A week or two is spent in the academic training in the school, and the same amount of time is allowed for practical work in the shop. This practical-theoretical training is the most common-sense method of education that high school or other boys have ever been fortunate enough to receive. The boy attending a school conducted on this plan has much to be thankful for.

From the recent impetus given to the coöperative school plan by the success of at least one such institution, it seems that educators are at last awaking to the fact that the real fundamental purpose of education is to enable us to do better the things which society through business and industry expects of us.

How it must hurt some of the old academicians to see the practical work-shop training, with grease and overalls as necessary adjuncts, supersede the "culture" of the older schools, too many of which still flourish.

To the engineer who had to struggle against the most adverse circumstances, first, for the essentials of a common school education, and second, for a training in power-plant practice, the coöperative school seems beyond reality.

The graduates of such schools will make excellent men for the power plant. Unlike some high-school graduates beginning an engineering career, they will have had most of the conceit drawn out of them by contact with actual working conditions. Most of these schools provide a training in machine-shop practice, a good knowledge of which is indeed valuable to the engineer.

The coöperative schools are sure to become more numerous. Manufacturers are glad to give their support to the plan, because boys from such schools make excellent employees.

This movement sounds a note of warning to young men who hope to become engineers, and who have not had the advantages of a good schooling. It means that they must give much time to the study of power-plant work so that they will be able to compete with their more fortunate brothers. Chief engineers can do a wonderful lot of good for young men who have not had the opportunities to get a training in the high school, or even in the higher grades of the grammar school. Mathematics and English are the subjects most needed as a basis for the education and training of such young men, and these subjects have of late been so simplified that their essentials may be mastered by diligent study. By making special provision for the training of these men in the many phases of power-plant work by making each watch engineer an instructor to the younger men as advocated by the Institute of Operating Engineers, the poor, but worthy ambitious young man will at least have a chance of competing with the more fortunate graduate of the coöperative high school.

Systematic Inspection

Only by careful and frequent inspecting and repairing can the equipment of the power plant be kept in the best condition. It is a first principle of power-plant operation that the equipment should be so maintained, but even the newest and most uptodate equipment will deteriorate rapidly if it does not receive adequate attention. Not only will the plant become inefficient and run down if it does not receive the attention that it should, but the equipment will soon become unsafe to operate.

This disease is not peculiar to the power plant alone. Every physical thing in the universe suffers change in the lapse of time. The more delicate and fine the quality of the material, the more rapidly will it disintegrate. Metal will oxidize and corrode. Wood will rot. Bearing surfaces will wear away. Parts will weaken under repeated stresses. This will occur under either static or dynamic stresses. A steel bridge is subject to deterioration just as surely as a steam engine. The power-plant owner or manager who has not taken these facts into account is the victim of his own carelessness or ignorance.

The first step in the maintenance of equipment is thorough and systematic inspection. The equipment should be thoroughly inspected at regular intervals. It is not enough to know that the boiler is washed out every two weeks. It is not enough to know that the engine is free from knocks and pounds. These are easy to attend to, but it is the elusive little things which are difficult to detect before the damage is done. Are the steam gages all correct? Are the blowoff valves tight? Are the relief valves free? Are the safety valves properly set? Are the feed-water lines free from scale and other obstructions? Are the feed pumps in proper working condition? Is the auxiliary equipment in good operating condition? All these and many more equally important facts may only be made known by careful and systematic inspection.

It is generally understood to be the duty of every operator to report any indications of trouble or cases that require attention or repair, as soon as he observes them. This is exactly the thing to do. Each operator should be trained to do this as a part of the specific performance of his duty. In addition to this it would be well to assign to one man the duty of making a careful general inspection of the plant at regular and frequent intervals. The inspector should receive assistance from the operator of the set of equipment which he is inspecting. All reasonable precautions should be taken to detect imperfect and impaired operation. Nothing should be slighted because it is out of sight or difficult of access. All in-

stances of neglect, corrosion, accumulation of dirt, lack of paint or other protection, excessive wear and incipient failure should be reported. As an aid to the process, a checking list of equipment to be inspected and irregularities to watch out for would be of value. The inspection should result in an accurate report covering the condition of the plant.

After the inspection has been made and the report completed, it should be acted upon at the earliest possible moment. If temporary repairs are necessary pending the opportunity for permanent repairs, they should be made at once. The permanent repairs should be made as soon as practicable. In power-plant operation it is not best to neglect permanent repairs simply because the equipment is still able to run. The report of such an inspection obviously is of little value unless it is acted upon promptly.

⁂

Lubrication of Air Compressors

In the proper lubrication of the air cylinder of a compressor, probably the most important fact to bear in mind is that the oil should be used sparingly. Some operating engineers take it for granted that an air cylinder requires just as much oil as a steam cylinder and, accordingly, apply as large a quantity in the one as in the other. This assumption and procedure, however, are entirely wrong and if these engineers, or oilers, would cut down the amount of lubricant fed into the air cylinder they would be surprised at the better results they would obtain.

An excess of lubricant means not only a waste of that amount of oil, but other losses and troubles mentioned later. These losses result in a higher operating cost than necessary and, while a reduction in the aggregate cost of operating, due to a lower consumption of cylinder oil, might be very trifling where only one or two small compressors are employed, nevertheless in a fairly large station such a reduction would be noticeable. Even in a small station there is no more excuse for waste, be it deliberate or through ignorance, than in the larger one and any saving, no matter how small, will reflect to the operating man's credit.

In addition to increasing the expense for oil, excessive lubrication also results in more rapid accumulation of combustible matter on the interior surfaces of the cylinder heads as well as on the valves. Further, there is a greater tendency for the dust drawn in through the suction to adhere to the interior parts. This means more work for the operator which can largely be eliminated so that there are benefits resulting from careful attention to lubrication which may be directly enjoyed by the operator even if he is not given credit for low operating costs. In ordinary air-compressor practice and for common size cylinders, it has been found that from one to three drops of oil every five minutes will sufficiently lubricate the air cylinder. It is also a good rule to always close the lubricators immediately before the compressor is shut down.

Next in importance to proper care and attention in the lubrication of air compressors is the selection of the best suited oil. To make this selection is not always easy, as it frequently involves rather exhaustive experiments and tests and also depends largely on the amount of compression, design of compressor, etc. Careful tests of various kinds of oils should first be made to determine the flash point, viscosity and so on. In general, nothing but a high-grade mineral oil having a flash point, say above 525 deg. F., should be used. An oil containing too high a percentage of carbon should also be avoided or, in other words, an oil should be selected which will leave but very little or no carbon deposit after it is volatilized. The reasons for this are obvious. When oils are used which volatilize readily, or have a low flash point, the gases, generated by the heat of compression, pass into the discharge pipe and receivers and do not require a very high temperature to ignite. If the oil is of a coking nature it carbonizes on the air heads and valves and prevents the latter from operating properly, often resulting in some form of accident. The importance of using the most suitable oil for the purpose is, therefore, quite apparent.

The explosions that sometimes occur in air compressors are caused mainly by the ignition of combustible matter deposited on the walls of the discharge pipe and in the valve ports. As all oils contain more or less of this matter, the interior parts of the machine should be carefully inspected at certain intervals, the frequency of which will depend to some extent upon the character of the oil used. Any deposit that may have accumulated as a result of the use of oil, which has been acted upon by the high temperature of the air should be carefully removed. For this purpose ordinary soap suds may be fed into the cylinder through the regular oil cup. This application should be continued for several hours, the length of time depending upon the quantity of deposit existing. Care should be taken, however, not to let the machine lie idle with soap suds remaining in it; otherwise the parts effected will tend to rust. To avoid this possibility it is advisable to stop the feeding of soap suds a short time before shutting down the compressor and commence feeding oil.

The receiver and pipes into which the compressor discharges should be blown out regularly to remove any oil and water that might have accumulated and especially should the discharge valves be inspected and cleaned at regular intervals because if they stick they are likely to admit hot compressed air from the receiver back into the cylinder, thereby increasing the temperature of the air to such a high point before compression that it will reach the flash point of the oil during compression. It might also be added that the intake pipes should be so arranged that the free air is drawn in from the outside rather than from the engine room. This is quite important, because cold air gives a higher volumetric efficiency to the compressor, which means economy of power. Besides, it is also an effective way of decreasing the likelihood of explosions.

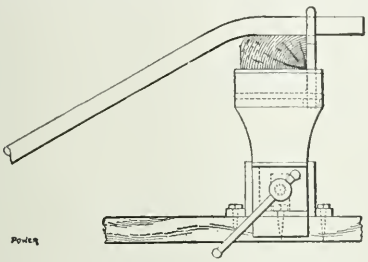
⁂

As compared with the 38 feet per second, which is considered the limit in safe speed for a cast-iron flywheel, some of the peripheral speeds attained by the disks of steam turbines are striking. In a paper entitled "Recent Developments in Curtis Steam Turbines" recently presented to the Manchester Association of Engineers, R. F. Halliwell says: "The highest peripheral speed which it is possible to employ is probably found in the 300-horsepower DeLaval turbine, in which with a 30-inch wheel running at 10,000 revolutions per minute, a velocity of over 1300 feet per second is reached.

READERS WITH SOMETHING TO SAY

An Emergency Pipe Bender

Desiring to bend a piece of ¾-in. conduit, and not finding anything suitable with which to bend it, I took an ordinary ½-in. eye-bolt, screwed a nut on it and clamped it in the vise as shown in the illustration. Then rounding one side of a wooden block to be used as a fulcrum, I found that bends and offsets could be easily formed.



Pipe Bender Made of Eye-bolt and Block of Wood

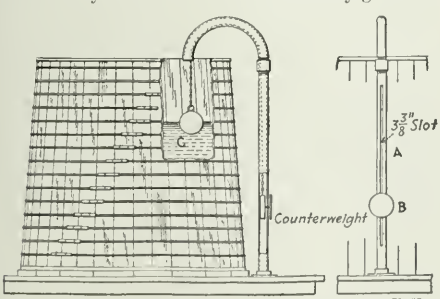
This bender could doubtless be improved upon, but it does exceptionally well in an emergency. As the fulcrum is made of wood, it does not kink the pipe as does an ordinary bender, or, what is commonly called, a "hicky." The wood block should be made of oak or maple.

Grover M. Hardy.

Selina, Kan.

Water Level Indicator

The illustration shows an indicator used to show the height of water in tanks on top of buildings. We have tried several designs of water-level indicators and found that while they worked well in summer they gave trouble



Water-level Indicator for Roof Tank

in winter, due to water freezing on the chain connecting the float with the indicator hand. As ice would accumulate on this chain it would not allow the indicator to register the proper water level. The indicator shown is made of 2-in. pipe in the form of a return bend of about 2-ft. radius. A slot *A* is cut in the straight pipe, and in it a pin carrying the tin plate *B* slides, with the rising or falling of the water level. This tin plate is connected with a chain that runs inside the pipe, and at the tank end is connected with the float *C*.

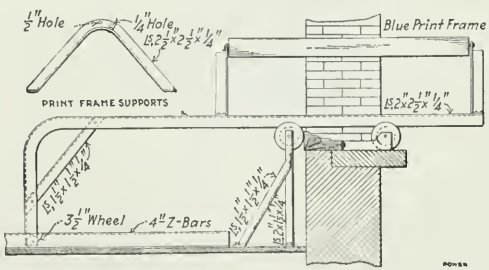
This indicator works well, as very little ice accumulates on the chain, and such as there is, does not interfere with the operation of the indicator; in fact, it makes it work better, as the ice offers less resistance to the travel of the chain through the pipe than does the bare chain.

Harry Biehl.

Philadelphia, Penn.

Disappearing Blueprint Frame and Carriage

At times, to secure a proper amount of sunlight, it is desirable, or perhaps even necessary, to place a blueprint frame on the front or side of a prominent building. In such cases the usual type of carriage running on a fixed track supported by brackets fastened to the outside of the building is objectionable because it is unsightly. A disappearing track and carriage showing only while in service is required. The one shown herewith has been in use several years and has proved very satisfactory.



Showing Construction of Disappearing Blueprint Frame and Carriage

The method of construction and operation is readily apparent. The frame, large enough to take tracings 36x 48 in., is mounted on a carriage made of angle iron and arranged to move in and out of a window on groove wheels held loosely on a ½-in. axle.

The wheels on the window ledge are set out as far as possible from the ledge, being held in place by brackets fastened to the window sill. The Z-bars should be long enough to serve as girders for the rear of the carriage when it is being drawn in; they also prevent the carriage from tipping up when pushed out. To allow the frame to be turned in any position directly toward the sun it is pivoted on ½-in. pins, one at each end. At one end a second pin, ¼ in. in diameter and 3 in. from the pivot pin, is arranged to slide into holes in a brass plate on the frame, thus holding it rigidly in any desired

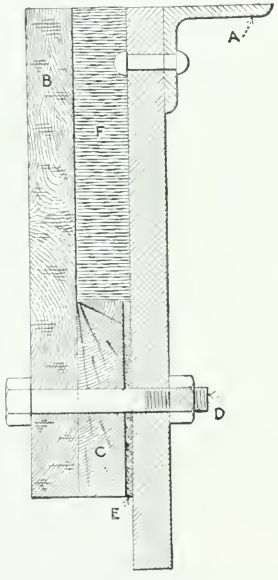
position. Unless the height from the window sill to the floor is unusually low a platform will be needed to stand on to conveniently reach the frame so that prints can be easily put in and taken out.

F. G. Hechler.

Troy, New York.

Stopping Leak in Submerged Tank

The accompanying sketch illustrates the manner in which a temporary repair was made to a submerged condenser tank, where the sides of the tank riveted to the angle iron *A* had rusted badly, allowing a number of rivets to be pulled out. In the illustration, *B* is a ½x6-in. yellow pine board; *C* is a ½x3-in. yellow pine piece, and *D* is a ⅜-in. bolt. Five of these were placed at 18-



Boards, Pitch and Feet on Side of Tank to Stop Leak

in. centers around the tank. About 6 in. below the top of the tank is a piece of folded felt *E* thoroughly painted with asphalt. At *F* is shown pitch which was poured in while hot. An inexpensive repair of this kind prolongs the life of a tank for a year or so until the deterioration of other parts justifies the installation of a new tank.

G. A. Robertson.

Louisville, Ky.

Compression vs. Cylinder Condensation

The experiments of Prof. Dwelshauvers-Dery, where he practically and definitely demonstrated that an early closing of the exhaust valve in a steam engine, causing compression before admission, is an uneconomical way of heating the cylinder walls, seemed to be contradicated by the tests of the performance of the Uniflow engine, in which high compression is a salient feature, indirectly productive of economical results. The contradiction, though apparent, is not real, and compression is not economical, but an early closing of an exhaust valve will not only cause compression, but will also prevent or reduce reëvaporation of the liquid during the exhaust stroke; and will thereby reduce the initial condensation due to contact with the cylinder walls cooled by reëvaporation during exhaust.

It might perhaps be claimed that by closing the exhaust valve before all the moisture has been removed, the cylinder will accumulate too much liquid, detrimental to the proper action of the working fluid (steam under pressure), but it must be remembered that the liquid removed by reëvaporation on the cylinder walls, is again replaced by initial condensation of live steam. As the latent heat of steam at high pressure amounts to less heat per pound than the latent heat required for vaporization of liquid at exhaust pressure, prevention of reëvaporation during the exhaust might even reduce the average moisture. A pound of water evaporated at 212 deg. will remove 970.4 B.t.u. from the cylinder walls, while the latent heat that a pound of steam at 115 lb. absolute can furnish is only about 880 B.t.u.

The loss due to reëvaporation during exhaust is greatest when the steam contains moisture at the throttle, because a pound of moisture or liquid at 115 lb. absolute contains only about 129 B.t.u. above the heat of the water at 212 deg., and that pound of moisture, if reëvaporated during exhaust, will carry away 970.4 B.t.u., a loss of

$$970.4 - 129 = 841.4 \ B.t.u.$$

Any such loss, to be made up by live steam entering at 115 lb. pressure with 1010 B.t.u. per lb. above the heat of the liquid at 212 deg. and leaving as steam through the exhaust with 970.4 B.t.u. per lb., will be made up at the rate of

$$1010 - 970.4 = 39.6 \ B.t.u.$$

per pound condensed.

A pound of moisture reëvaporated on the cylinder walls during exhaust will cause the condensation of

$$841.4 \div 39.6 = 21.25 \ lb.$$

of steam at 115 lb. pressure. This is a good reason for using a separator at the throttle so that the steam enters the cylinder as dry as possible.

If heat transmission was instantaneous the cylinder walls would be alternately as hot as live steam and as cold as exhaust, and the limits to cylinder condensation and reëvaporation would be set by the specific heat of the metal times the weight of the metal affected. However, all the liquid cannot be reëvaporated during the exhaust. It takes time to transmit heat, and the time depends on the conductivity of the metal and the fluid, the amount of surface affected, the amount of the difference in temperature, the amount of moisture in the steam and the nature of the agitation.

In compound engines the reduced range of temperature decreases heat transmission.

In Uniflow engines the reëvaporation of moisture during exhaust is almost entirely prevented, and the cylinder walls are so warm that but little condensation takes place.

In any engine, if the time of reëvaporation during exhaust is reduced, as by compression, the initial condensation is also reduced. Furthermore, when a piston has reached the greatest velocity in the stroke, and its motion is retarded as the crank gets near the center, the

moisture swept by the piston is thrown against the cylinder head, causing an agitative effect and increased facility for reëvaporation. If the exhaust valve then is closed, so that the agitation takes place under an increasing pressure there is no more reëvaporation during that stroke.

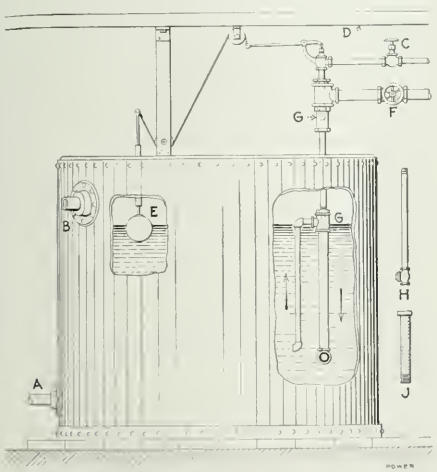
Superheat, compounding, steam jackets, etc., are means employed to prevent or reduce cylinder condensation, and permit the steam to expand as nearly as possible like a perfect gas. If there was no reëvaporation during exhaust, the cylinder condensation would only be enough to make up for heat lost externally by the cylinder, heads, rod, etc.; but reëvaporation during exhaust increases cylinder condensation to such an extent that it can be economical to use compression as a remedy.

C. Osborne.

New York City.

Serious Water Hammer in Feed-water Tank

We had a 1000-gal. tank made, in which to collect the condensation from the heating system and other sources, and to supply the boiler-feed pump through the pipe *A*. A pipe leads from the flange *B* to the atmosphere and contains no valve. Cold water is supplied through valve *C* and the valve *D*, the water level being regulated by the float *E*. Exhaust steam is supplied through the valve *F* at about 2 lb. pressure, and according to theory should



Connections to Feed-water Heater to Prevent Water-hammer

form a siphon condenser in the mixing chambers *GG* and incidentally the water should circulate in the pipe as shown by the arrows.

So much for theory; but this is what happened when the steam was turned on: Severe water-hammer was set up in the heater, which sounded like the blows of a heavy sledge hammer, and, notwithstanding that the heater was open to the atmosphere, this heavy tank jumped and danced away from its place on the brick floor, the vibrations being transmitted throughout the building.

The trouble was remedied entirely by embedding the tank in 3 ft. of concrete as a foundation, and by screwing the pipe *H* with a check valve attached, into one of the elbows, in the up-pipe shown by the arrow, and attaching the capped perforated pipe *J* to the other pipe. This stopped all vibration and only a very slight rumbling is occasionally heard.

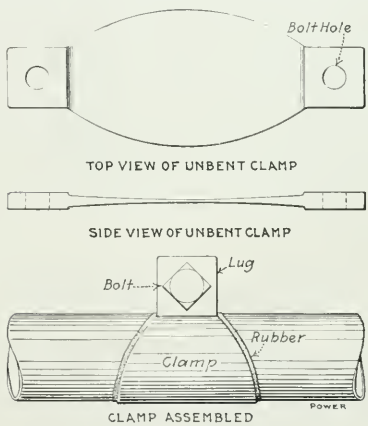
Charles Haeusser.

Albany, N. Y.

Pipe Clamp for Leaky Pipes

A simple device by which a leak in any size water, steam or gas pipe may be temporarily repaired is shown in the accompanying illustrations. It can be made by a blacksmith at a slight cost by ordering several of one size at a time.

This device is of wrought iron and for pipe under 2½ in. should be slightly less than $\frac{1}{16}$ in. thick at the bottom,



Homemade Pipe Clamp

so as to be somewhat flexible, and gradually increasing to $\frac{1}{8}$ in. in thickness at the base of the projections or lugs, at the top. The latter should be about $\frac{1}{4}$ in. thick, have a height and width of 1 in., also a hole in the center of each lug to take a $\frac{3}{8}$-in. bolt, to fasten the clamp to the pipe. The greatest width of the clamp should be at the extreme bottom and about $1\frac{3}{4}$ times the nominal diameter of the pipe for which it is made. The clamp should be made so it will be in contact with the pipe through an arc of about 300 deg.

When using this device a piece of cloth insertion rubber, at least $\frac{1}{16}$ in. thick and a little larger than the clamp should be placed over the leak in the pipe, and the clamp placed over it. A $\frac{3}{8}$-in. bolt is put through the holes in the lugs, and after placing a washer and nut on it, is tightened up.

I have used this clamp successfully in repairing leaks in piping that were almost inaccessible, and where, if the lengths had been removed, a considerable loss of time, labor and money would have resulted. This device can be applied without reducing the pressure on the system.

E. Oster.

Cincinnati, Ohio.

QUESTIONS BEFORE THE HOUSE

Acid in Oil May Cause Corrosion

In the Nov. 26 issue, H. K. Wilson speaks of trouble with a crosshead caused by corrosion of the threads. I believe this trouble to be caused by sulphuric acid in the engine oil. This acid is used in treating oil in some processes and should be neutralized, but sometimes this is not done.

The acid remains inert as long as no water is present, but on coming in contact with moisture from the stuffing-box leakage it becomes active, corroding the iron. A simple test for sulphuric acid is to make a saturated solution of barium chloride in distilled water. Take about an ounce of the oil, and dilute it with an equal quantity of benzine or gasoline to make the oil more limpid and add a few drops of the barium solution.

If sulphuric acid is present a white precipitate will form and if it does so the oil should not be used where it will come in contact with moisture. Some years ago I had trouble with a pair of wristpin boxes from the same cause, and they were nearly ruined before I found and removed the cause of the trouble.

C. A. Green.

Cleveland Ohio.

Rising Tide Fills Receiver

The letter by Mr. Adams, under the above caption, page 614 of the Oct. 22 issue, shows the necessity of carefully studying the piping and equipment in power plants. Frequently engineers taking charge of new or strange plants find many little faults in the piping which have been overlooked by the steamfitters, and, if left as found, would conduce to damage to the equipment.

Relative to the plant mentioned by Mr. Adams, a check valve should have been placed in the drain pipe above the funnel; this would have prevented the water from being drawn back into the receiver. Most compound engines have a steam trap connected to the receiver, and a check valve between the receiver and the drain pipe. Then only the condensate from the steam as it is passed through the piping and receiver can accumulate in the receiver while the tide is high.

In a plant in this locality some years ago, the cylinder heads of three engines were blown off as the engines were being started for the day's run. This plant was run noncondensing. The exhaust line ran along under the floor, through the engine room to the boiler room, which was 70 or 80 ft. distant, where it was then connected into an open feed-water heater. The exhaust main had gradually filled with water during the night, because the float valve which controlled the city water supply to the heater became inoperative and allowed the full city pressure to flow into the heater, the overflow not being able to pass out all the water, allowed it to rise high enough in the heater to flood the exhaust line. This exhaust line was trapped, but the trap could not take care of the extra water, and so the pipe became full during the night.

These conditions were not known to the engineer who started one of the engines, which made but a revolution or two, when the entrapped water in the cylinder, being compressed by the piston, blew off the low-pressure cylinder head. Thinking that this water was due to condensation in the steam-supply pipe, he immediately started one of the other engines and the same thing happened to this one. By this time he was so thoroughly excited, and as it was after the usual starting time, he jumped to the throttle of the third engine and, opening it, caused the cylinder head to be blown out as it had been on the other two. The real cause of the trouble was discovered, as usual, when it was too late to do any good.

R. A. Cultra.

Cambridge, Mass.

Measuring Air from Compressor

As a rough and ready method, Prof. Fessenden's suggestions in the Dec. 31 issue seem good, but I disagree with his assertion that his method can be made very accurate, and I take the liberty of questioning both its practical and theoretical correctness. In the course of the article he says that "the volume and temperature remain constant and the pressure and weight decrease as the air escapes through the partly open valve *B*." The very first principle of air compression and expansion is that the temperature will change with the pressure. The test procedure is to expand the air in the tank from a pressure 10 or 15 lb. above normal, down to some pressure below normal, then plot a curve of pressure drop with time, from which the tangent angle will give the first differential, or rate of flow. It seems to me that this assumes the expansion to follow the equation, $W = PV \div RT$, which he has given, assuming, as he says, that the temperature shall remain constant. A single trial will convince anyone that the temperature in the tank will not remain constant. I have in midsummer formed good-sized chunks of ice, which come shooting out of a receiver drain, by allowing the air in the receiver to expand down from 100-lb. gage to atmosphere. There is little or no cooling of the air after passing the orifice, but if the body of air in the receiver is allowed to expand that way, the expanding air in the receiver will grow intensely cold and will carry out chunks of frozen moisture.

When the pressure is increased to 10 or 15 lb. above normal, the air gets hotter because the compression range is increased; but not very much hotter, as regards the entire body of air in the receiver, because the new, more highly heated air is a very small proportion of the tank contents. Now, however, when the entire tankful is allowed to expand back to normal pressure, there is a very rapid temperature drop, and when normal pressure is reached again, the temperature will be much below normal. Thus the condition of flow at normal pressure may be entirely different from what it was at first.

It is true that the volume flowing from an orifice varies only with the square root of the absolute temperature, so if the original pressure increase is but slight, it may be that the curve of expansion will be true enough at the point of normal pressure to give a rough approximation to the flow rate. That it is theoretically correct, as claimed, I doubt very much.

A little further along he says that the thermometer must be "carefully calibrated, and that the temperature of the air should remain the same when the readings for the pressure-time curve are taken as when valve *B* is adjusted." To carefully calibrate a thermometer is easy, but as to the last injunction: how does he do it? I have seen the mercury skip up and down in a thermometer at a lively rate as air was compressed and expanded in a receiver. This naturally brings up the question: if expansion of the air in the receiver lowers its temperature, why will it not be equally raised by pumping more air into the tank, and so raise the pressure?

Some reader will say, "it does." But try this: Have an air receiver connected to the shop air line, but with the air valve closed and the pressure in the receiver at atmosphere. Now open the valve to admit air from the shop line, all outlets from the receiver being closed. If the shop line air is cold, as it usually is, will the receiver become hot when the pressure within it is raised to, say 100 lb., with the cold shop line air? Any increase in the heat in the air would mean an increase of energy in the air, and there is no place for this energy to have come from. It could not come from the compressor, as this reasoning will prove: Suppose the compressor to be running at constant speed and blowing off all its capacity at full pressure to atmosphere from a bypass. Further, assume for ease of reasoning that, by the time the air has reached the blowoff, it has cooled down to atmospheric temperature in the shop line, as it usually does. Now, the compressor is developing a certain horsepower, delivering a certain amount of air at, say 100-lb. pressure, 60 deg. F. Suddenly close the blowoff and open the valve into the receiver, filling the latter with the cold air, but throttling the flow so as to maintain the compressor discharge pressure at exactly 100 lb. until the receiver is full.

During this process the conditions at the compressor must have remained constant. If it was delivering cold air to the blowoff, it must deliver cold air to the receiver and the latter is then filled with cold air. The air in the receiver cannot increase in temperature, because if it did it would contain more energy than it had when passing out of the blowoff, and it cannot contain more energy because the compressor horsepower has very clearly remained constant. The air passing from the line pipe into the receiver may grow a shade colder, but only a shade, because the pressure in the air line has not been allowed to drop.

If, however, the shop line is closed off and the air in the receiver allowed to blow down to atmosphere, pieces of ice will shoot out of the receiver blowoff when the receiver pressure has gotten down to about 10 lb.

I have never noticed any increase in temperature in filling a tank with air at normal temperature from the 100-lb. shop line. I have, however, often noticed marked increase in temperature in a receiver filled with air and then further compressed in the receiver by pumping water into the bottom, thus decreasing the air volume and increasing the pressure. Increase of pressure by decrease of volume will increase air temperature; but increase of pressure by crowding in more air at normal temperature does not appear to increase the temperature, nor does a consideration of the energy transfers lead to such a conclusion. Expansion of air through an orifice, or valve, as in opening a cock on an air line, will scarcely decrease the temperature of the escaped air at all; but expansion of a body of air from one pressure to another, as in blowing down an air receiver, so that the pressure within the receiver is decreased, will rapidly decrease the temperature of the air within the receiver.

R. S. Bayard.

New York City.

Explosions in Air Lines

The article by Frank Richards, of July 30, 1912, issue of Power, has brought forth considerable discussion in regard to dangerous explosions in receivers of compressed-air systems. It seems to be the consensus of opinion that these explosions, sometimes fatal, result from an abnormal increase in temperature, which is sufficient to vaporize the grease which lines the discharge pipe and receiver, thus supplying a mixture of oil and air which explodes when the temperature rises sufficiently. No cause, however, for this rise in temperature is offered.

It is only natural that the result of the explosion should appear in the receiver since the receiver is the weakest part of the system on account of its large size and comparatively thin shell. Anyone who is seriously interested in this subject might very profitably look up the details of the explosion of a four-stage air compressor at the Redstone plant of the H. C. Frick Coke Co., Brownfield, Penn. To guard against the repetition of a former violent explosion, a recording thermometer had been installed in the pipe line for the outgoing air close to the compressor. Fusible plugs were also attached to the discharge pipe as a further safeguard.

When the compressor was working normally, day in and day out, the temperature of the discharged air was ordinarily about 240 deg. F. and practically never more than 250 deg. F. On the day of the explosion, the temperature for the first part of the morning was the same as usual, but at 11 a.m. the temperature started to increase and reached about 270 deg. F., indicating trouble. The temperature remained at approximately this point for 3½ hr. so that there was plenty of time for the engineer in charge to discover the unusual condition and to shut down the compressor for investigation. Apparently the engineer took a long chance and as a result an internal explosion took place at three o'clock in the afternoon. The chart record shows that the temperature rose to 620 deg. F. almost instantaneously, being checked here by the blowing out of a fusible plug.

The cause of the rise in temperature in air compressor lines has been given careful consideration by engineers of large coal companies using compressed air for power purposes. It is generally believed that the high temperatures are a result of the continued recompressing of air in the compressor cylinder, due to improper action of the air valves. Heat is generated when air is compressed and if the valves do not prevent this heated air from getting back into the cylinder to be compressed again, the air will become hotter and hotter, depending on the efficiency of

the water-cooling system, until finally the temperature will reach a point where the lubricating oil and the grease lining the discharge pipe and receiver will become vaporized and finally ignite, resulting in an explosion.

Normal working temperatures of air leaving compressors vary somewhat according to the compressor and the efficiency of the cooling system. Blowing engines, such as are used for blast furnaces and for bessemer converters, compress the air to about 10 to 30 lb. per sq.in. Neither the air cylinder nor the discharged air are water-cooled and the temperature of the air in the blast main will usually remain at about 300 deg. F. under proper conditions. The blast main becomes lined with grease, the same as the discharge pipe for high-pressure air but, as the air is at a fairly low pressure, a fire results instead of the explosion in high-pressure lines. These fires are a result of the same trouble, improper working of the valves. In the case of blowing engines, however, the fires take place within the time of about three or four revolutions of the engine after the valve trouble occurs, because no cooling water is used. The effect of water cooling in air compressors prevents an instantaneous explosion when the valves are not working properly, thus allowing sufficient time to shut down and investigate. As previously stated, the temperature of the discharged air will largely depend on the amount of cooling applied. The air from the four-stage compressor at Brownfield, Penn., was normal at 220 to 250 deg. F. Records from three-stage air compressors in the same district show normal temperatures of 275 to 310 deg. F. A single-stage compressor would likely discharge air at something under 300 deg. F. with normal conditions, and this is safely below the ignition point of good lubricating oil.

To prevent these disastrous explosions, very nearly all of the coal operators using multiple-stage air compressors in the western Pennsylvania district have equipped their compressors with recording thermometers so that the engineer in charge will have complete information of the temperature of the discharged air and so that there will be records of these temperatures for the superintendent. One of the large coke companies has also devised an automatic electrical emergency shutdown device which is operated from the thermometers. Another method, which is less expensive, consists of having a gong sounded when the temperature rises sufficiently to close electric contact in the thermometer, thus giving warning to the engineer that the compressor is not working properly.

The suggestion of Thomas Baker, in POWER for Dec. 31, 1912, is good, that "Only the very best grade of air-compressor oil obtainable for lubricating the cylinders be used." It is quite likely also that the amount of oil for the compressors could be considerably reduced.

Pittsburgh, Penn. R. B. ANTHONY.

World Beating Discoveries

Many such wonders as are referred to editorially under the above heading, in the Dec. 3 issue, have a basis of truth, but fail because they are out of proportion.

Take, as an example, the proposed production of liquid carbon dioxide from furnace gases by methods which involve centrifugal separation. Consider this idea in the light of the kinetic theory of gases. This theory postulates a gas as made up of innumerable small particles, endowed by heat with mobile power and darting to and fro at enormous velocities. The particles possess weight, and are therefore subject to the attraction of gravity.

It can be shown that the atmosphere about the earth exists, where it is as a compromise between gravitation and molecular velocity. This being true it should be possible, in a closed vessel of mixed gases, well insulated from changes of temperature which would cause currents and induce mixing, to show a greater percentage of the heavier gases, collected by settling at the bottom of the vessel. It should also be possible by producing a whirling movement in any smooth container, so far to increase the different gravitational influence on molecules of different weights as to cause the heavier ones to be separated toward the outer part of the vortex. But the added energy would be so small a part of the total molecular energy that the practical effect would be little.

If two gases be separately imprisoned in a vessel with a central sliding door between them, then when the door is removed, those molecules which were by the door will begin to diffuse into the next compartment. This power of diffusion varies inversely as the square root of the density of a gas. Thus if the two gases are oxygen and hydrogen the densities of which are 16 and 1, their diffusive energy will be as 1 to 4, and the first molecules of hydrogen will penetrate 4 ft. into the mass of oxygen in the same time as occupied by the molecules of oxygen in penetrating only 1 ft. into the mass of hydrogen. This diffusion runs counter to other influences and enables oxygen to find its way to the floor of a mine in spite of the superior gravitational pull upon the carbon dioxide. Thus diffusion and temperature-produced currents mix up the atmosphere preventing gravitational stratification.

Since 14 cu.ft. of air weighs one pound and the atmosphere weighs upon each square inch about 15 lb. the height of the atmosphere, were it uniformly dense vertically, would be about 28,000 ft. And since its content of carbon dioxide is one in 10,000, this gas would cover the earth's surface to the depth of nearly three feet. No small animal could live at the sea level.

That we owe mixture to diffusion can be shown by removing the heat which gives to gas molecules this energy of motion. Gases liquify at different pressures and temperatures, and air can be separated into its constituents by compression at a very low temperature, the more easily liquified gases being drained off before the less easily liquified gases lose their gaseous state. The reverse effect, or distillation, has long been employed to separate mixed solids and liquids.

At a velocity of 1920 ft. per sec., a gas molecule, starting upward from the earth would ascend for

$$1920 \div 32 = 60 \text{ sec.}$$

In that time it would reach a height of $16t^2$ ft., or

$$3600 \times 16 = 57{,}600 \text{ ft.}$$

or 11 miles, which would be the depth of the atmosphere for a gas of that molecular velocity. The moon possesses little or no gas because its gravitation is insufficient to restrain the molecular energy with which gaseous molecules travel from it. With such a view of molecular gaseous energy it is obvious that gases cannot be much influenced by such movements as can be mechanically impressed upon them and would-be revolutionaries in the engineering world would do well first to acquire a knowledge of some of the basic laws against which they may be running counter.

London, England. W. H. BOOTH.

INQUIRIES OF GENERAL INTEREST

Water Temperature in an Open Heater—Why cannot water be raised above a temperature of 212 deg. in an open heater?

K. F. N.

Because, in an open heater the water is under atmospheric pressure, and its highest attainable temperature is 212 deg. F.; above, that temperature it becomes steam under atmospheric pressure.

Motor Windings—What is the difference in the effect of a differential and of a cumulative winding upon the speed of a motor?

C. F. N.

The effect of the differential winding is to increase the speed as the load increases, whereas that of the cumulative winding is to increase the speed as the load decreases.

Reversing Motor—How may a shunt-wound motor be reversed?

H. F. C.

By interchanging the field connections or the line connections at the brushes, or, in a bipolar machine, by shifting the brushes 180 deg.; in a four-pole machine, 90 deg.; in an eight-pole, 45 deg., etc.

Fire Crack on Boiler—What causes a fire crack on a boiler; where do they most often appear and are they dangerous?

G. N.

A fire crack, as distinguished from a rupture due to a strain, is caused by the action of the furnace heat. These cracks sometimes occur in the body of a boiler sheet or along its edge, and occasionally in the rivet head or between the rivets. Usually the crack begins at the fire surface. It is dangerous only when the crack increases in depth, thereby impairing the strength of the material.

Evaporation in Draft Gage—How can evaporation in the draft gage be prevented?

J. S. H.

A good way is to place about one-half inch of a light oil on the surface of the water in each leg of the U-tube, being careful that there is the same amount of oil in each. Then the difference between the level in the two legs may be read off, giving the draft in inches of water the same as though no oil was used. Covering the surface with oil prevents evaporation of the water, but care should be taken that when the draft gage is disconnected in the open atmosphere the water level stands the same in each leg of the U-tube.

CO_2, CO and H_2O—What is meant by CO_2, CO and H_2O?

J. P. M.

CO_2 is the chemical symbol for carbonic acid gas and means that in each molecule of the gas there are one atom of carbon and two atoms of oxygen. CO is the symbol for carbonous acid gas, each molecule of which is formed of one atom of carbon and one atom of oxygen. This gas is the result of incomplete combustion, for CO can still burn to CO_2. Consequently, when CO is the product of combustion, not so much heat results from a given quantity of fuel as when the product is CO_2. H_2O is the symbol for water and water vapor, each molecule of which is the combination of two atoms of hydrogen and one of oxygen.

Position of Gage-Cocks—Why are the gage-cocks ranged in a slanting line in the boiler head?

J. E. R.

If the holes in the head were in a vertical line, bringing one cock plumb above or below another, the cocks would come so close together for indicating the desired differences of water level as to leave too small a ligament of metal between the holes made in the head to receive the gage-cock connections. Hence the line is slanted from the vertical. Another reason for slanting the line of cocks is to prevent the discharge of one cock from falling on another, and also to leave sufficient space between the cocks for fitting them up and for operating them.

Coal Consumption—Is 14¼ lb. of buckwheat coal per square foot of grate area a fair average of coal consumption for a water-tube boiler with a steam blower discharging under the grate?

G. E.

Burning 14 to 19 lb. of buckwheat coal per square foot of grate would be only a fair average with natural draft. With forced draft it should be possible to burn as high as 25 to 35 lb. per square foot of grate with good results. In using forced draft it is assumed that only as much boiler capacity is employed as may be necessary. With insufficient natural draft and where forced draft is necessary, it is better to force the boilers beyond their rated capacity and employ only as many boilers as may be necessary.

Thickness of Boiler Heads—Is there a formula or rule for finding the thickness of boiler heads for a given thickness of plate? For example, should a boiler with ½-in. plates and over have ½-in. heads?

E. W. H.

The thickness of boiler heads of return tubular boilers is not determined by a mathematical calculation but empirically from practice. The Massachusetts rule requires that boilers 42 in. in diameter or under shall have heads ⅜-in. thick; from 42 to 54 in. diameter, inclusive, $\frac{7}{16}$-in. heads; 54 to 72 in. diameter, inclusive, ½-in. heads and over 72 in. diameter, $\frac{9}{16}$-in. heads.

Sampling Coal—How should a sample of coal be selected for a proximate analysis?

C. A. H.

Sampling may be done according to the A. S. M. E. Code for Conducting Boiler Trials, the rules for which may be found in various text and hand books. A simple method that will give very close results is as follows: Select equal samples from various parts of the coal pile. Thoroughly mix and crush them, then halve the quantity, quarter it, and so on, repeatedly divide it, until only as much remains as is required for the analysis. It is well to repeat the mixing frequently and also the crushing if the coal was not originally pretty finely powdered.

Pumping Pressure—Against what pressure can water be forced by a pump having 7-in. water and 5-in. steam cylinders, taking steam at 80 lb. pressure?

K. F. N.

Theoretically, the pressures in the two cylinders will be inversely as their areas, and the latter are proportional to the squares of the diameters. Then the pressure in the water cylinder would be

$$\frac{25 \times 80}{49} = 40.8 \text{ lb.}$$

Practically, on account of friction, and the actual mean effective pressure being less than the initial pressure, even with steam supposed to be taken during the full stroke, at least 10 per cent. less pressure would be all that could be pumped against or around 35 lb.

Proximate Analysis—What is the proximate analysis of coal and how is it obtained?

H. A. C.

What is known as the proximate analysis of a fuel is one which determines the relative proportions in the fuel of fixed carbon, volatile matter, moisture and ash. Progressive heating separates these parts and weighing the remainder at each stage enables computing the various percentages. At a temperature of 250 to 300 deg. F., all the moisture will be driven off. Further heating to a red heat will remove the volatile matter, and at a white heat the carbon will unite with oxygen to form CO_2, leaving the ash as the final residue.

The principal apparatus required for ordinary boiler room use includes a crucible about 6 in. in diameter, a cover for the crucible and sensitive scales, such as are used by druggists. For the heating, the most available means will answer, as the boiler furnace itself. The crucible may be held in the furnace with tongs or on an old shovel. For the first heating, to drive off the moisture, the crucible may be set just inside the fire door on the dead plate. A blacksmith's forge or a large enough Bunsen burner may also be used for the whole range of heating. To begin with, the empty weight of the crucible must be taken so that it may be deducted from the final weight to get the weight of ash.

ENGINEERS' STUDY COURSE

Mensuration—Part I

Mensuration is really "short-hand" geometry, because it treats of the measurements of lines, angles, surfaces and solids, while geometry is the science which proposes and demonstrates the art of measuring. Mensuration is especially valuable to the engineer, for by knowing how to use it he can measure the volume of tanks and vessels of all shapes, the area of surfaces, regular or irregular.

Lines and Angles

A *geometrical* line has length but not breadth nor thickness. Lines may be straight or curved.

A *straight line* is one that does not change in direction throughout its length, as the line *AF* in Fig. 1, or the lines *AE, BF, CG* and *DH* in Fig. 2.

A *curved line* changes in direction at every point. Straight lines are designated by two letters, while curved lines are usually designated by three letters. The lines *ACE, CEG, EGA*, which describe the circle in Fig. 2, are curved lines.

Parallel lines are lines which are the same distance apart throughout their entire length, as the edges of the top and bottom crosshead guides of an engine.

A line is *perpendicular* to another when it meets the other line at right angles. Thus the line *CO*, Fig. 2, is perpendicular to the line *AE*.

A *vertical line* is a line pointing toward the center of the earth, such as a plumb line, or line holding a suspended plumb-bob.

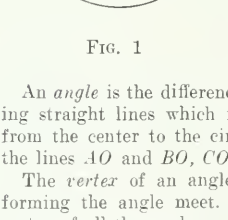


Fig. 1

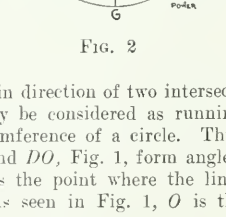


Fig. 2

An *angle* is the difference in direction of two intersecting straight lines which may be considered as running from the center to the circumference of a circle. Thus the lines *AO* and *BO, CO* and *DO*, Fig. 1, form angles.

The *vertex* of an angle is the point where the lines forming the angle meet. As seen in Fig. 1, *O* is the vertex of all the angles.

To understand the angle we must understand the circle. The circumference of the circle is considered as being divided into 360 equal parts, each called a *degree*. A degree is divided into 60 equal parts, each of which is termed a *minute*. The minute in turn is divided into 60 equal parts, each of which is termed a *second*. From this we see that the length of a degree, minute or second measured on the circumference will vary for different-sized circles, but that *a degree of any circle is equal to* $\frac{1}{360}$ *of its circumference*. The degree, minute and second are expressed, °, ′, ″ respectively. Thus for the expression, 20° 16′ 50″, we read 20 degrees, 16 minutes, 50 seconds.

Any circle contains four right angles. Then a right angle must be equal to $\frac{360}{4} = 90$ deg. Thus in Fig. 2 *COE, EOG, GOA* and *AOC* are right angles, or 90-degree angles. A 45-degree angle must be $\frac{90}{2}$, thus *AOB, COD, DOE*, etc., in Fig. 2, are 45-degree angles.

An *obtuse angle* is any angle greater than a right angle. Thus the angle *BOE*, Fig. 2, is an obtuse angle. An *acute angle* is any angle less than a right angle; as the angle *DOE*, Fig. 2.

When a straight line, as *BO*, Fig. 2, meets another line *AE*, between its ends, two angles, *BOA* and *BOE*, are formed. Angles formed in this manner are termed *adjacent angles*.

From the foregoing we see that no matter how many lines we draw through the center of a line, such as *AE* Fig. 2, or how many lines we cause to meet at a point *O* on a line *AF*, Fig. 1, the sum of all the angles formed cannot be more than four right angles in the case of Fig. 2, nor more than two right angles in the case of Fig. 1. Then if we are told how many lines, spaced equally, are drawn through the center of a circle, we can easily find how many degrees there are in the angle included between any two of these lines. Thus suppose there are eight lines, as in the case of the center line of the arms of an 8-arm flywheel. Then the angle made by any two adjacent arms is $\frac{360}{8} = 45$ deg.

The Circle

As we all know, the circle is a figure bounded by a curved line, termed its circumference, every point of which is equally distant from a point called the center.

An *arc* of a circle is any part of its circumference, as *ABC*, Fig. 3. If we know how many degrees there are in an arc we know directly what angle will be formed by lines drawn from its extremes or ends to the center of the circle which it represents. Conversely, if two lines drawn from the center to the circumference form an angle of a given number of degrees they will meet the circumference at the ends of an arc of the same number of degrees.

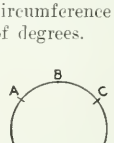


Fig. 3

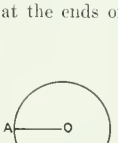


Fig. 4

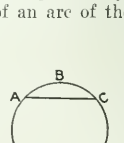


Fig. 5

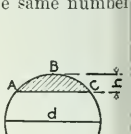


Fig. 6

The *radius* of a circle is a straight line drawn from the center to the circumference, as the line *OA*, Fig. 4. When this line extends all the way across the circle, as at *D*, Fig. 6, it is called a diameter.

A *chord* of a circle is a straight line joining any two points on the circumference, as the line *AC*, joining the ends of the arc *ABC*, Fig. 5.

A *segment* of a circle is the area included between a chord and the arc, as the shaded part in Fig. 6. The height of a segment of a circle is the distance *h*, Fig. 6. A segment may be less, equal to, or greater than a semicircle (half circle).

A *sector* of a circle is a part of a circle shaped like a piece of pie. Referring to Fig. 2, the area included between the lines *BOCB* is a sector.

PRACTICE QUESTIONS

(1) (a) How many right angles in an angle of 186 deg.? (b) How many 45-deg. angles?
(2) Is a 45-deg. angle an obtuse or an acute angle?
(3) How many minutes in 2.067 right angles?

Coppus Turbo Blower

The turbine of the Coppus boiler turbo-blower, Fig. 1, is of the impulse type. Upon the periphery of the wheel are over 200 closely spaced, smooth-drawn steel buckets. The bucket wheel is revolved within the turbine casing by the live-steam jets. The steam chamber is of minimum dimensions, to reduce radiation losses, being located in a current of cold air. The steam passes through three nozzles, one of which is connected directly to the steam-supply pipe while steam to the other two may be shut off for light loads by hand-operated valves. With this method of control, steam is used at full pressure. The nozzles direct the steam against the buckets at an angle of 20 deg. to the plane of rotation. A sectional view of the turbine is shown in Fig. 2.

Exhaust steam leaves at the bottom and passes through an elbow formed in the lower side of the casing and discharges in an upward direction, and thoroughly mingles with the current of air, raising its temperature before entering the ashpit. If desired, the exhaust steam can be piped to a heating or drying system.

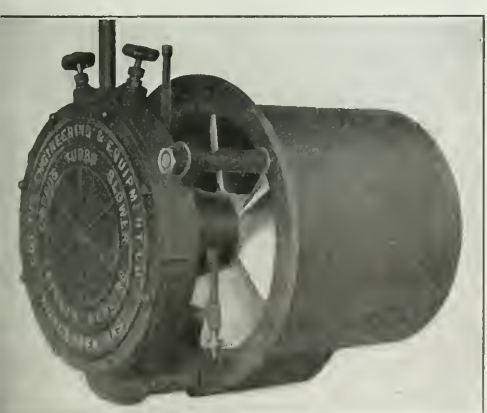


FIG. 1. COPPUS TURBO-BLOWER

The turbine and fan shaft is supported by ball bearings at both ends, protected against dirt and dust by oil-tight covers. The aluminum fan wheel is of the propeller type. A balanced valve in the turbo-steam line regulates the draft. The lever of the valve is connected to the damper regulator so that when the steam pressure drops, the damper is opened as is also the valve, both operating together. The blower then increases its revolutions and runs at the necessary speed until the steam gage registerers the predetermined pressure, when the damper closes and the blower slows down automatically.

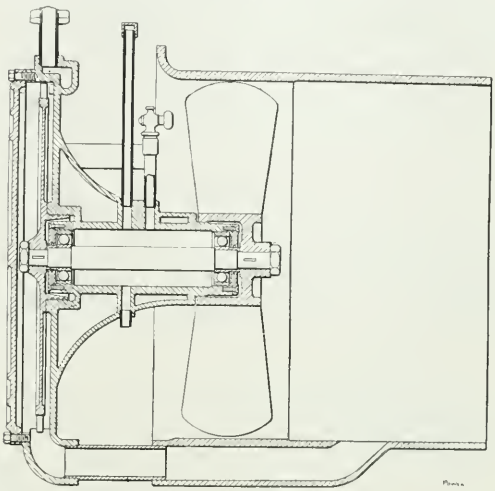


FIG. 2. SECTION THROUGH TURBO-BLOWER

This blower unit is made by the Coppus Engineering & Equipment Co., 66 School St., Worcester, Mass.

Records for the Isolated Plant

In a comparison between any isolated plant and a central station, it is very important to know exactly the cost of producing power, particularly in the case of the former, so that the rate may be compared to that offered by the central station. To obtain some valuable data along this line the Engineers' Blue Room Club, of Boston, is distributing plant data sheets to be filled out by engineers in and around Boston and in other cities throughout New England.

A summary of the data on a large number of these records should be of great assistance in determining the status of any particular plant, and in deciding on economical results generally. The data sheet is made up under headings of General Data, Cost of Power, Valuation of Equipment, Labor and Hours of Operation, Distribution of Power, Distribution of Expenditures, Detail of Operation and Equipment, Engines and Turbines, Elevators, Refrigerating Plant, Heating System, Ventilating System and Hot-water House System. Under each subhead a number of items are to be filled out, so that complete information on the type and size of equipment and cost of operation will appear in the record.

The effect of vanadium in plain carbon-steel castings is to increase the elastic limit about 30 per cent, giving a much higher proportion of available strength for the same ultimate strength.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Jacob Shurt, chief engineer over to the Magnolia lighting station, according to the social column of the "Magnolia Mirror," intends spending Saturday night with his parents in Plainfield. Good luck, Jake—and good night, Shurt!

⁂

Our old boyhood chum, Castor Oil, is again to the fore. "Gas Power" says it is not generally known that castor oil is one of the best of lubricants for gas-engine cylinders. Good old "Cas." While we could never really learn to love him, in our sober moments we always respected him for his good work.

⁂

A Brooklyn mechanical engineer hopes to make all the heating engineers look like a discarded ice-floe. He wants Congress to help build a huge jetty over the Grand Banks, thus choking off the Labrador Current, which is now cooling the Gulf Stream. Then we'll have no more fogs and late springs, you can live in Siberia if you want to (some people have to), and Greenland's icy mountains will be likened to India's coral strands. Twenty million is the price, and it's cheap if it works.

⁂

Some of our contemporaries certainly do distort the meaning of their headlines. "Electrical World" says: "Mr. Arthur Williams on the Electric Vehicle." Sounds too much like a new type of water wagon, and we know better of Mr. Williams.

⁂

It's a fine summer weather this winter, Mawrus. So fine it has encouraged the Weather Bureau to say it can dope out the weather a year in advance if given sufficient appropriation. On the other hand, medical science says that if we could know the future we would go dippy. Good chance for some team-work here.

⁂

While our admiration for the efficiency disciples is unbounded, we must take exception to Dr. Blackford's statement that blondes and brunettes figure in the work. We see the danger signal on our domiciliary semaphore showing red right now. The doctor says some things about blondes and brunettes that no father of a family could make his wife believe were in accordance with any set of steam tables we know of.

⁂

"The locomotive raced up the track, overtook the workman, and, wonderful to relate, hurled him unhurt into the woods alongside"—Daily press. It would have been even more "wonderful" if the locomotive had left the track and chased him through the woods.

⁂

Doctor Tolman, of the Museum of Safety, says that too many pants-pressers and yaps are, through political pull, made safety inspectors of shops and plants. "Give us inspectors who can inspect. Also, what's the use of asking the prospective inspector of flywheels to give the distance between New York and San Francisco?" he asks. That's it, what's the use?

⁂

According to a learned professor, "between impure water and auto-intoxication there is a relation." Further discovery reveals the fact that some of the "relations" are B. Aerogenes, B. Enteriditis and B. Anaerobicus. Cricky! we thought these chaps had gone home to Greece to help fight the Turks.

⁂

Some apparently unreasonable things do happen now and again. A water tower from the top down burns up (or down, and out); a fire-engine house is leveled by the demon flames; a retired sea-captain, 40 years at sea, is drowned in his bathtub at home; a veteran of 400, more or less, Indian skirmishes keeps his boots on until he gets home, and then runs a rusty nail in his toe and ptomaine (no, not "toe" this time, printer) poison carries him off. Truly, as Goethe said, or might have said, the more we live, the longer we find we are out.

American Roller Bearing

A new make of roller bearing, designed to run without lubricants, is manufactured by the American Roller Bearing Co., Farmers' Bank Building, Pittsburgh, Penn.

This bearing consists of an outer hardened-steel easing and an inner hardened-steel sleeve. Between these are

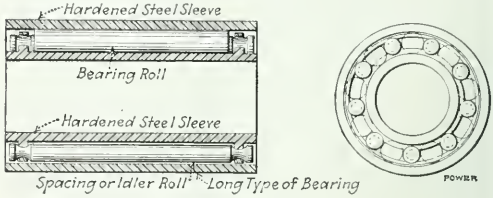


FIG. 1. SECTION THROUGH BEARING

two sets of rollers of two sizes, the larger being the bearing rollers, the smaller the spacing or idler rollers. These are shown in Fig. 1. The small rollers are ground and run on a track, and are held in place by retaining rings.

The bearing is suitable for all kinds of work. When used for line shafting, the outer sleeve fits into a shell, held in place in the hanger in the usual manner.

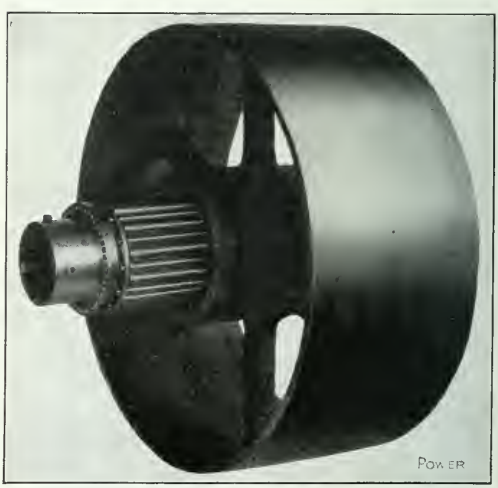


FIG. 2. ROLLER BEARING IN LOOSE PULLEY

In Fig. 2 is shown a loose pulley fitted with this kind of a bearing. It is also made with a thrust bearing, as shown.

⁂

The efficiency of compressed air can be greatly increased by reheating. The gains are both direct and indirect, the chief direct gain being in the greatly increased efficiency of fuel used in the heating stoves as compared with the effect when coal is burned under boilers. It is commonly stated, and the statement is fairly correct, that when 1 lb. of coal is burned in a reheater stove the commercial effect is as great as when 3 lb. are burned under a boiler. The increase in commercial efficiency when reheating air from 60 deg. F. to 400 deg. F. may be put at 35 per cent. The indirect gains are better lubrication of the compressed-air engine; less investment required, as a smaller plant will be needed; reduction of compressor engine friction as compared with the useful work done.

Developments in Oil Burning*

By E. H. Peabody

SYNOPSIS—Characteristics and methods of handling mechanical atomizers, effect of heating oil, control of capacity, use of heavy oil, furnace design, Peabody mechanical atomizer and flat spray atomizers.

With the continued increase in oil production the use of this fuel is rapidly extending, particularly for marine purposes, and it seems worth while to point out some of the main characteristics of the mechanical atomizer and modern methods of handling it. In attempting this the writer will of necessity have to look at the subject from his own point of view, and in the light of his own experience and the experiments carried out by The Babcock & Wilcox Co.

Commodore Isherwood's conclusions of some forty years ago hold good today; namely, that the atomization of the oil, as distinguished from vaporization or gasification in the burner, "is the only method that has been attended with success." The vapor systems, while successful in metallurgical work, have no standing in boiler practice as they show no gain in efficiency but, on the contrary, result in poor capacity, the latter feature alone making them undesirable for marine use.

FIG. 1 SCHÜTTE SPRAYER

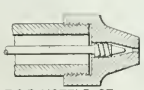


FIG. 2 NOZZLE OF HOWDEN BURNER

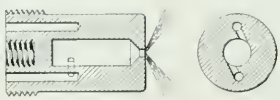
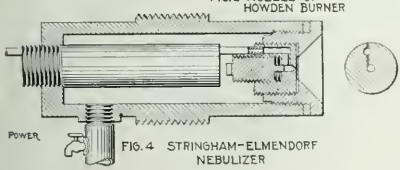
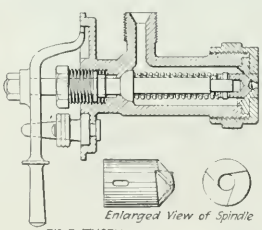


FIG. 3 JONES BURNER



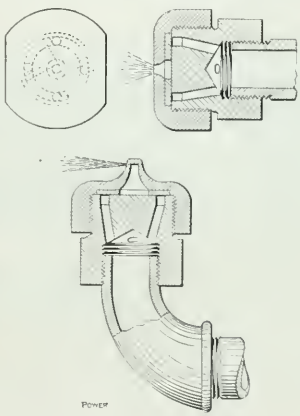
POWER

FIG. 4 STRINGHAM-ELMENDORF NEBULIZER



Enlarged View of Spindle

FIG. 5 THORNYCROFT BURNER



POWER

FIG. 6. PEABODY FLAT SPRAY MECHANICAL ATOMIZER

Effect of Heating Oil on Viscosity

The value of heating the oil is to reduce the viscosity of the liquid so that it can be forced through the small passages of the burner and given a rapid whirling effect sufficient to reduce it to a fine spray through the action of centrifugal force when liberated from the tip. While the viscosity is tremendously affected by changes in temperature at the lower ranges, very little difference in viscosity results with heating or cooling as the temperatures approach the flash-point.

With all ordinary oils it may be considered that heating within 50 deg. F. of the flash-point will be sufficient to render the oil suitable for use with the mechanical burner, and in the case of many of the lighter oils even this heating is unnecessary, the oil being sufficiently limpid at ordinary atmospheric temperatures.

*Abstract of paper read before the Society of Naval Architects and Marine Engineers, New York City.

Mechanical Spraying

Several methods of spraying oil by mechanical means have been suggested, such as forcing the liquid through a very fine aperture, forcing a jet of oil at high velocity against some object or against another oil jet, throwing the oil off from a rapidly revolving table or disk, or giving the liquid itself a whirling motion and reducing it to spray by centrifugal force.

In 1902 the writer tried the first idea and succeeded in making a very poor flat-flame mechanical atomizer by forcing the oil between two flat surfaces pressed closely together, and in 1907, some of the other schemes. The experiment of making two round jets of oil strike each other on the principle of the acetylene burner, resulted in a flat spray—not fine enough, however, with heavy oils to be practicable. A mechanical atomizer, or, as it was called, a "self-atomizer," consisting of eight small jets meeting at a central point, was patented in England in 1904 by Charles Ferdinand de Kierkowski Steuart. It is a good example of spraying by forcing jets of oil to strike each other, but otherwise has attained no importance in the art.

The only method of atomizing fuel oil mechanically which has attained any practical success is that wherein the oil is given a whirling motion inside the burner tip. There are two distinct means of doing this, first, by forcing the oil through a passage of helical form, like a screw thread, and second, by delivering the oil tangentially to a circular chamber from which there is a central outlet.

Fig. 1 is an illustration of the first form, the "spraying nozzle" patented in the United States in 1895 by L. Schütte. Another adaptation of the same idea is shown in a patent taken out in England in 1899 by James Howden, Fig. 2. He refers to heating the oil by means of live or exhaust steam or the waste gases, pumping it into an accumulator or air receiver for neutralizing the

pulsations of the pump, and then projecting the oil into the furnace in the form of fine jets or spray by passing it through a nozzle having helical grooves on a part of the spindle within the nozzle, so as to impart a whirling motion to the oil. Howden's burner is adjustable in that the taper spindle moves "up and down" in the taper passage leading to the nozzle orifice. This movement of the spindle increases or decreases the area of the outlet passage, thus controlling the amount of oil delivered by the burner, but the helical passage is not affected.

The idea of delivering the oil tangentially to a chamber inside the nozzle is shown in a burner patented in England by Albert Edward Jones in 1907, Fig. 3. This invention contemplates the use of a gas or vapor in combination with a combustible liquid and is not strictly a mechanical atomizer, but the device is almost a diagrammatic illustration of the tangential principle. It may be considered that oil is forced into both tangential passages, or that only one is used, this depending only on the whirling motion of the oil to cause the spraying.

A so called "nebulizer of the heavier hydrocarbons," patented in this country in 1908 by Stringham and Ehmendorf, is a good illustration of the further development of the tangential principle and is shown in Fig. 4. This apparatus was water-cooled, a precaution not found necessary in connection with boiler furnaces.

Modification or combinations of the tangential and helical forms of burners are frequently encountered in the art, and an illustration of one of these is shown in Fig. 5. This is an ingenious burner patented in England by Sir John Thornycroft in 1906, in which it may be noticed that the oil passages within the tip are made variable in area of cross-section by an adjustment of the spindle, thus varying the quantity of oil delivered without alteration of either oil pressure or size of outlet passage. This renders the burner adjustable like the Howden, though by a different process, in that in the Howden burner the helical passages remain unaltered and only the outlet orifice is changed.

Control of Capacity

This matter of adjustability of an oil burner, that is, the ability to change the quantity of oil delivered in a given time without changing the oil pressure or the velocity of the liquid through the tip, while attractive and perhaps well sustained in theory, has no particular value in practice. It is a fact that the simpler forms of burners which do not possess this feature are quite as, if not more, successful in regular operation on shipboard. The manipulation of the oil pressure acting on all burners at once presents in itself a simple means for the control of output through a wide range; a good burner will atomize moderately heavy oil with an oil pressure as low as 30 lb., and from that up to 200 or above. If this range is insufficient to meet the variable steam requirements, then it is easier and better to shut down a portion of the burners entirely than to attempt to adjust each individual burner separately, particularly as it is important to regulate the quantity of air for combustion admitted to the furnace at the same time the quantity of oil is varied. This air supply can easily be controlled for all burners by regulating the draft pressure, and the air can be closed off entirely when a burner is shut down. This puts the question of air supply more into the hands of the designer, requiring the operator to determine only the proper conditions of draft pressure for the plant as a whole, at the required capacity.

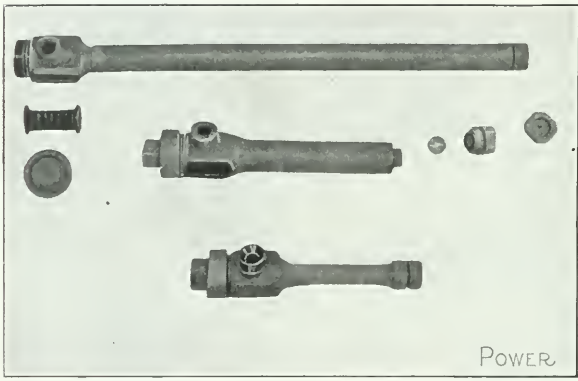


Fig. 7. Peabody Mechanical Atomizer

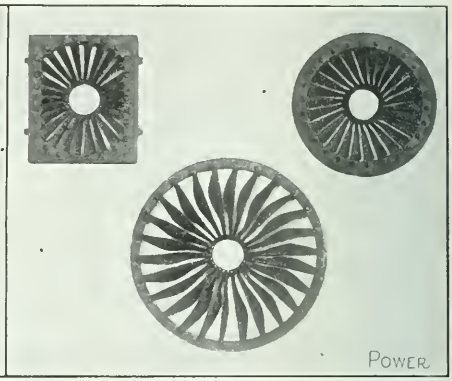


Fig. 8. Impeller Plates

Effect on Heating

Another means of varying the quantity of oil delivered by all burners in addition to alteration of oil pressure is available in alteration of oil temperature. Generally speaking, under working conditions any increase in temperature of the oil results in decreased capacity of the burners, the pressure remaining the same. The reverse is the case at low temperatures, the critical point depending on the relationship between viscosity and specific volume of the oil in question.

Requirements of Mechanical Burners

It will be obvious, if oil is to be atomized by centrifugal force, that the best spray will be obtained by giving the oil the maximum whirling motion and reducing to a minimum the friction in the burner so that the whirling motion once obtained shall not be diminished before the oil is liberated. It would appear that the tests should be:

1. How heavy an oil will a burner thoroughly atomize?
2. What pressure and temperature are necessary?

3. What degree of simplicity has been attained in the design?

Use of Heavy Oil

Any apparatus which will not handle heavy oil will have a very limited usefulness. Already the market is beginning to be supplied with very heavy oils from Mexico, there is considerable crude oil in California below 15 deg. gravity, and the tendency will be more and more to use the heavier residuums. In a few years we will be using oils of 12 to 15 deg. Baumé as commonly as we are consuming oil of 27 and 30 deg. gravity today.

The Babcock & Wilcox Co. recently received from The Texas Co., for experimental purposes, some Mexican crude oil having the following characteristics:

Specific gravity at 60 deg. F.	0.981
Degrees Baume at 60 deg. F.	12 6
Moisture and silt	3.5
Flash-point	310
Burning point	347
B.t.u per pound (oil as received)	17,551

In appearance this oil was black and at temperatures of about 80 deg. very sticky and viscous. On heating to 212 deg. it turned to foam owing to the presence of so much water, and this failed to separate out, a sample of the oil being thinned down with ether to determine the percentage. Ordinary settling tanks would have been practically useless as the oil was so near the specific gravity of water. This oil was, however, successfully sprayed and burned under natural draft, on being heated to 270 deg. at a pressure of 165 lb. A slight amount of smoke was formed which disappeared on a slight increase in the furnace draft above 0.12 in. of water. The most noteworthy feature of the experiment was that the capacity fell off about 40 per cent. from that obtained with the same apparatus with oil of 18 gravity.

The accompanying table of densities is given for convenient reference.

DENSITY OF OIL

Degrees Baume	Specific Gravity	Pounds per Gallon	Degrees Baume	Specific Gravity	Pounds per Gallon
12	0 986	8 22	24	0 913	7 61
14	0 973	8 11	26	0 901	7 51
16	0 960	8 00	28	0 890	7 42
18	0 948	7 90	30	0 880	7 33
20	0 936	7 80	32	0 869	7 24
22	0 924	7 70			

Peabody Mechanical Atomizer

In the light of experiments begun in 1907 we have come to believe that the best rotative effect on the oil is produced by the tangential delivery method, and it seems plain that the best way to reduce friction is to reduce the amount of surface to which the oil is exposed in its travels through the burner after it begins to whirl and until its exit from the tip. Great importance is attached to simplicity in everything connected with oil burning. The oil burner itself should be of simple construction, easily taken apart, and so designed that when taken apart all the small passages and wearing surfaces will be exposed for inspection, cleaning and repair.

In the writer's burner, Fig. 7, oil is delivered under pressure to an annular channel cut into the face of a nozzle upon which is screwed a tip having a small central chamber communicating with a discharge orifice. Between the nozzle and the tip a thin washer or disk is inserted and held firmly in place. This has a hole in the center corresponding with the diameter of the central chamber of the tip, and small slots or ducts, extending tangentially from the edges of the central opening outward toward the periphery of the washer, long enough to overlap the annular channel of the nozzle and put it in communication with the central chamber. The effect is that when the burner is assembled with the washer in place, oil is delivered through the ducts tangentially to the central chamber, where it rapidly revolves and almost immediately is discharged through the orifice in the tip.

Character of Mechanical Spray and Effect on Combustion

No mechanical atomizer produces a revolving spray, but the particles of oil fly off in straight lines under the influence of centrifugal force, thus forming a hollow, conical spray. The fineness of this spray, i. e., the minuteness of the particles forming it, has a most important bearing on the results obtained in the furnace. It is possible with some forms of steam atomizers to atomize oil so finely that no flame at all will be produced, the incandescent combustion chamber being filled with a clear, invisible gas and every brick being discernible.

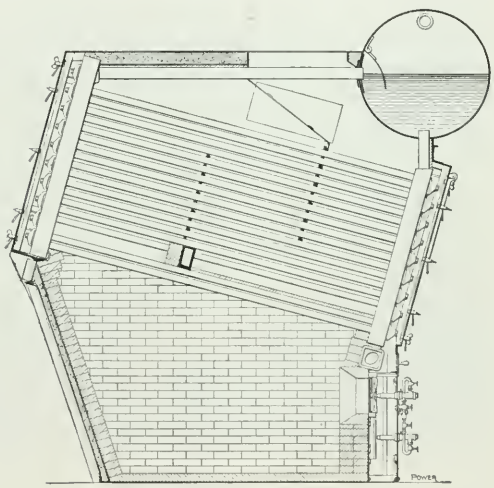


Fig. 9. Furnace of Babcock & Wilcox Boiler

It is doubtful if this condition of flameless combustion can be produced with mechanical atomizers and heavy oil, nor is it desirable under any circumstances, for the simple reason that it costs too much.

With production of flame, however, furnace design assumes an added importance, for the flame must be distributed evenly and without localizing on the heating surfaces of the boiler, and the gases must be given time and space in which to expand and burn as nearly as possible to completion before being cooled and the flame extinguished by contact with the tubes of the boiler. These points become exceedingly vital when the boiler is forced to the requirements now demanded in naval service.

Furnace Design

Having an atomizer that will produce a fine spray with heavy oil and which is simple, reliable and easily handled, the problem becomes one, not of oil burner, but of furnace

design and air distribution. Our work has been carried on, until recently, entirely with the Babcock & Wilcox marine boiler, a design having a furnace suited for any volatile fuel and particularly for oil. A longitudinal section through this boiler fitted with mechanical atomizers is shown in Fig. 9. The characteristics of this furnace are: Large volume in proportion to the heating surface of the boiler; upward slope of the roof toward the rear, resulting in increase in height and volume in the direction of the entering oil spray and thus providing room for the expansion and diffusion of the gases; small amount of boiler heating surface exposed, and, on the contrary, large exposed surface of incandescent refractory material, thus tending to maintain high furnace temperature and promote complete and rapid combustion of the oil; tubes almost parallel with the path of the oil spray injected into the furnace from the front, thus promoting proper distribution of the gases along the tubes and preventing local overheating; outlet from the furnace at the point most remote from the location of the atomizers, insuring long travel of the gases; and, finally, means for bringing the heated products of combustion into the closest possible contact with the entire amount of heating surface of the boiler, discharging the waste gases into the uptake at temperatures but little above that of the steam generated.

[Reference was made in the paper to the tests made on the steam yacht "Idalia" and the guarantee tests for the "Wyoming," in which coal, oil and a combination of the two were used as fuel. The results of the tests with oil fuel were published in POWER of Aug. 1, 1911. In both cases the flat-blade impeller plate was found to be most suitable, and a considerable number of small burners and impeller plates were preferable to a few of larger size. In the "Wyoming" an evaporation from and at 212 deg. F. of 13.16 lb. of water per hour was obtained and a combustion of 13.69 lb. of oil per cu.ft. of furnace volume, which is equivalent to about 15.34 lb. of coal per square foot of grate area in the same boiler.—EDITOR.]

FLAT SPRAY ATOMIZERS

Mention has been made of a flat-flame atomizer formed of two flat surfaces pressed together, and another consisting of two round oil jets striking together. Neither of these schemes seemed to promise very much in the way of material for development. Another form which does seem to possess some merit is illustrated in Fig. 6. This consists of a means for giving the oil a rapid whirling motion as in the case of the round-flame burner and then releasing the liquid through a slot in the side of the tip in a plane at right angles with the axis of revolution instead of through an orifice concentric with the axis. It is apparent that centrifugal force will here come into action as an atomizing agent but that the spray will be flat instead of conical.

(To be continued)

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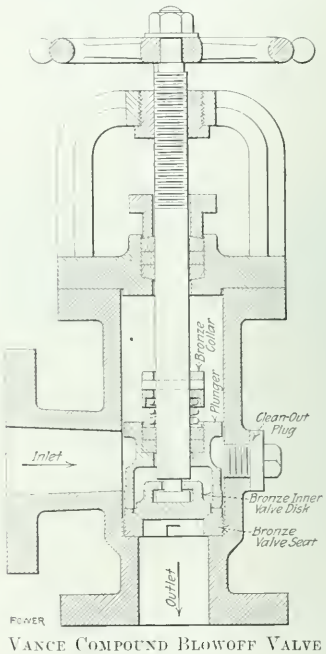
On an average a man dissipates about 2.5 kw.-hr. per day. This is spent partly in muscular action, partly in the production of heat in the maintenance of the body temperature against radiation. There is thus a continual power consumption of about 100 watts, or one-seventh of a horsepower. About one half of this is spent in maintaining the body temperature. The human body has about the same heating effect upon the surroundings as a 16-cp. carbon filament lamp.—"Scientific American."

Vance Compound Blowoff Valve

A new blowoff valve is being placed on the market by the George M. Newhall Engineering Co., Philadelphia, Penn. The feature of its construction is a double-disk arrangement to protect the valve seats from the action of sludge and scale coming from the boiler.

Referring to the illustration, the outside plunger protects the disk valve from coming in contact with any destructive elements, no matter how far the valve is open or closed. Each valve disk seats individually, the plunger first and then the disk.

When the plunger passes the inlet in closing, the flow is practically cut off, and only a thin sheet of water passes



VANCE COMPOUND BLOWOFF VALVE

over both seats to clear them of sediment, until the plunger seats; when tight, the disk valve seats with no water passing through. On opening, the disk valve leaves its seat first, because the spring holds the plunger in place until after the disk valve moves up into the protective covering of the plunger out of the way.

The disk valve works on a slip joint, and is easily removed. Precaution has also been taken to protect the valve seats by placing them below the direct line of the sludge as it comes from the boiler. These seats are removable for regrinding or renewing. All working parts are bronze. The valve stem screws through a bushing in the yoke of the valve. The stuffing-boxes are deep to insure room for sufficient packing to keep the valve stem tight. The valve is made extra heavy throughout.

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For utilization of the water power of Finland, and for conducting part of the energy obtained at St. Petersburg, a new Belgian share company will be established in Brussels with a capital of $6,000,000. A considerable number of international banks, it is said, are taking part in the subscription to the foundation capital.

Goulds Centrifugal Fire Pump and Power Head

A new design of centrifugal fire pump, made by the Goulds Manufacturing Co., Seneca Falls, N. Y., is furnished complete with pump, direct- or alternating-current motor, or steam turbine, bedplate and all fittings required by fire-insurance companies; it has also been approved by the Association of Mutual Factory Fire Insurance Companies.

Four sizes are made, with capacities of 500, 750, 1000 and 1500 gal. per min., for two, three, four and six effective fire streams respectively. All working parts are of bronze to prevent corrosive action from the water.

The 500-gal. equipment for two effective streams, with 250-ft. leads of smooth hose and 1⅛-in. hose nozzles, produces a nozzle pressure of 50 lb. per sq.in. and an effective stream in a modern wind reaching a vertical height of 70 ft. and a horizontal distance of 63 ft. The 50-hp. motor runs at 1700 r.p.m. The overall dimensions of the complete outfit are: Length, 9 ft. 7 in.; width, 6 ft. 3 in.; height, 4 ft. 9 in.

A new power head has also been developed for operating cylinders in deep wells in connection with pneumatic-pressure water-supply systems. In addition to pumping the water from the well, it also supplies the air pressure for the tank. Compressed air is obtained by a special air cylinder mounted on the frame near the top. The plunger of this air compressor is operated by a rod connected to the crank rod of the working head by an extension of the pin connecting the crank rod to the well rod. A pipe from the air cylinder connects it with the discharge of the working head. This air pipe contains a check valve and the necessary couplings. A cock is provided so that the air will not go to the tank when it is open and the outfit is relieved of air pressure when it is not needed.

By taking out the bolts which secure the well cover to the frame and disconnecting the well rod, the plunger can be withdrawn from the well without disturbing pipe connections or moving the working head. The gear ratio is 5 to 1 and the tight and loose pulleys supplied are 16x3 in.

Marine Engineers' Convention at Charleston, S. C.

The thirty-eighth annual convention of the Marine Engineers' Beneficial Association was held at Charleston, S. C., during the week commencing Monday, Jan. 20, with headquarters at the New Charleston Hotel.

There were 48 delegates present from all parts of the United States, and 16 supply houses were represented. The several sessions of the delegates were held in the banquet hall of the hotel, where considerable important business was transacted with dispatch. The delegates and visitors were warmly welcomed to Charleston by Mayor John P. Grace and other prominent city officials.

There was an enjoyable series of entertainments, including automobile rides for the ladies, an "oyster roast" at Schuetzen Park, an entertainment and ball at the German Artillery Hall, and a steamboat ride to Fort Sumter. The special feature of entertainment, which proved a fitting conclusion to this successful convention, was the smoker on Thursday night at the German Artillery Hall, to which the business men, manufacturers, city officials and other interested citizens of Charleston were invited. A splendid vaudeville performance was given and refreshments of all kinds were served.

The election of national officers by the Marine Engineers' Beneficial Association for the ensuing year resulted as follows: William F. Yates, president; David W. Miller, first vice-president; George H. Bowen, second vice-president; Charles N. Vosburgh, third vice-president; George A. Grubb, secretary; Albert J. Jones, treasurer; William S. Brown, Frank J. Houghton and Edwin P. Groff as members of the advisory board.

At the closing meeting of the Supplymen's Association the following officers were elected: Charles F. Heitzman, president; R. R. Row, vice-president; Charles A. Wilhoft, secretary-treasurer.

The next annual meeting will be held at Washington, D. C., in January, 1914.

Engineers and Guests at the Charleston Convention

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Tests of double check-valve systems are made every month by the water department of Hartford, Conn. Fourteen manufacturing companies in the city now maintain these systems on fire service pipes for their automatic sprinklers. The secondary water supplies are obtained from the Park River or other polluted sources so that they must be segregated from the city's mains carrying water for domestic use. It is important, however, that the check valves be in proper working order at all times to meet emergencies in the form of large fires. The valves, as described in the annual report of Caleb M. Saville, chief engineer, are fitted with leakage testing devices and automatic alarms which ring in the offices of the factory superintendents. The monthly tests, according to the report, have shown that the check valves are operating satisfactorily.

N. A. S. E. License Committee Report

The following is an abstract of a recent report made to John F. McGrath, national president of the National Association of Stationary Engineers, by the National License Committee, C. H. Wirmel, John J. Coughlin and James Rostron:

The National License Committee held a two-days' session beginning Saturday, Dec. 14, at Pittsburgh, Penn. Proposed bills submitted by the states of Indiana and Oregon, with a few minor modifications, were approved. The Indiana bill, submitted by Chairman Heeger of the state committee, and endorsed by all of the state engineers' organizations, provided for a board of examiners of four members, the chief examiner acting as president, and the examining, licensing and classification of engineers and firemen. The examination fee is $3, and the fee for renewals, to be made annually, is $3, thereby making the department self-sustaining. The examining board is authorized to reduce the fees when they exceed the expense of operating the department.

The Oregon bill, which combines an engineer's license law and a boiler-inspection law, is a model of its kind and framed to meet present-day requirements. It provides for a board of rules of four members, a chief inspector, 10 deputy inspectors and a secretary; all inspectors to be selected by the merit system. The fee for internal-boiler inspection is $5, and that for inspection while in operation, $2. It further provides for the examination, classification and licensing of engineers and firemen. The application fee is $1, and the license is issued for an indeterminate period to be revoked for cause and renewed upon affidavit, when destroyed or lost. Penalties of fines and imprisonment are provided for employers and engineers violating the law. The annual renewal and license fee is eliminated. This, together with the requirement that the engineer keep a daily record of the condition and repair of all boilers carrying over 251-lb. pressure, are two very important features that should commend the bill to the favorable consideration of both the steam user and the engineer.

Mr. Rostron reported that Delaware, having made four attempts to secure a state law, may compromise on an enabling act, thus giving cities the right to enact local ordinances; that Mr. Case, of New Jersey, has secured over 10,000 signatures to his petition for a license law, with good prospects of passage at the coming session of the legislature; that Mr. Lee, of the New York license committee, will call a meeting later to determine the future policy of the committee; that the Maryland committee reports progress on its proposed bill; that South Carolina, which some years ago made a futile effort to secure a law, again desires to take up the matter and will negotiate with the National License Committee to that end; that the prospect of presenting a bill to the Pennsylvania legislature during the coming session was likely.

Mr. Coughlin reported that as the Kentucky legislature would not meet until 1914, license work in that state would be deferred until that time; that prospects in Indiana, with all engineer's organizations united on a bill, looked favorable for its passage at the coming session of the legislature.

Mr. Wirmel reported favorably on the Michigan, Illinois and Wisconsin state bills and on the Aberdeen (S. D.) ordinance; that the work in Ohio to broaden the scope of the boiler-inspection law and to eliminate the engineers' license renewal fee would be submitted to the legislature. He was authorized to confer with National President McGrath as to lending financial assistance to the several state committees.

In response to numerous demands, the committee decided to secure the license and boiler-inspection laws of the national government, the several states and cities, and refer them to the coming national convention for compilation and publication. Mr. Rostron was assigned to look after the Eastern states and Messrs. Wirmel and Coughlin to the Central and Western states.

License Legislation in New Jersey

The combined associations of the New Jersey N. A. S. E. and the American Order of Steam Engineers have prepared a proposed "enabling" law to be presented to the legislative bodies of that state.

If passed it will empower the board of aldermen or other governing bodies of any municipality to provide by ordinance for the examination and certification of persons having charge of or operating stationary and portable steam engines and boilers. It requires that the charges made for examination and certification shall not exceed $2.

Electricians Make Brave Rescue

Charles Sanges and Frank Bettles, electricians of the Mobile Electric Co., Mobile, Ala., displayed rare bravery recently in rescuing two firemen who had been buried beneath the débris in a fire which destroyed the Mobile theater.

Manager Jackson, of the Mobile Electric Co., said: "These men at the risk of their lives, were lowered by ropes attached to their belts into the smoldering tons of brick to rescue the firemen. The red-hot bricks were removed and the two firemen released from their awful predicament. Although burned and blistered, the linemen went back to their work after receiving medical attention and resumed their daily duties."

N. A. S. E. Lantern Slide Catalog Read

The catalog of lantern slides on steam turbines issued by the National Association of Stationary Engineers is being sent out to the various associations. At the Kansas City convention the association directed that pictures be prepared to illustrate technical subjects and a scheme started for loaning these slides to subordinate associations.

Briefly, the plan is this: Custodians have been appointed in 12 cities who will take charge of the slides and issue them to associations on application. Fifteen duplicate sets are to be prepared, one for each custodian, with two sets in some of the larger districts. The slides on steam turbines have already been sent out; the second set, on steam boilers and stokers, will be sent shortly, followed by sets of pictures to illustrate gas power plants. Other subjects are in preparation.

Apparently the scheme is a good one, as within six days from the date the application blanks were issued, one of the custodians received 28 applications for the slides. Within the next month there will be three subjects in circulation and 15 duplicate copies. The N. A. S. E. will supply the associations as promptly as possible.

OBITUARY

JOHN B. PERKINS

John B. Perkins, of the John B. Perkins Co., Boston, died on Jan. 19 at his late home in Auburndale, Mass., after a lingering illness, at the age of 43.

Mr. Perkins' career began as an operating engineer. He was chief engineer of the Watertown pumping station before entering the employ of the Garlock Packing Co. some eleven years ago. Later he went with the Crosby Steam Gauge & Valve Co., and then became a manufacturers' agent, his business developing into the formation of the John B. Perkins Co. A man of strong personality and determination, many of Mr. Perkins' friends attribute the initial cause of his death to overwork.

PERSONALS

R. W. Williamson, for the past three years city electrician of Shreveport, La., and local representative of the Louisiana Fire Prevention Bureau, has tendered his resignation to accept a position with the Alabama Power Co.

Edwin M. McClintock, superintendent of stations of the Union Gas & Electric Co., Cincinnati, and William F. Vance, chief electrician of stations, have resigned to go with the Superior Carbon Specialty Co., of that city. Both were connected with the company over nineteen years.

Col. George W. Goethals, chairman and chief engineer of the Isthmian Canal Commission, was the guest of honor at a dinner given by the Lehigh University Club of New York, at the Hotel Astor, Jan. 27. Besides members of the club, a number of prominent engineers were invited guests.

Frank F. Fowle has severed his connection with the McGraw Publishing Co. as one of the editors of "Electrical World," and will resume his electrical engineering practice with offices at 66 Maiden Lane, New York City. As a consulting electrical engineer, Mr. Fowle is widely known. He is a member of the American Institute of Electrical Engineers, the Illuminating Engineering Society, the National Electric Light Association, the Railway Signal Association and the Technology Club of New York.

POWER

Vol. 37 NEW YORK, FEBRUARY 18, 1913 No. 7

Hasty Judgment Is Rash

"DON'T take any notice of what he says, he's only a helper anyway. He's been in the business a few days and now wants to give suggestions and advice."

One sometimes hears remarks of this nature even among machinists and engineers, but it behooves us all to think twice before rendering such a judgment. We may be quite unaware of important facts concerning the person offering advice, and as sometimes happens, the best of help and suggestions on various subjects may come from unexpected quarters.

All good ideas and suggestions do not necessarily come from the people who have grown gray in following the same line of business.

Years ago a lighthouse was to be built in the English Channel to mark a dangerous spot. One of the most noted architects and builders of the day was entrusted with the work, and so confident was he, because of his previous record and experience, that upon its completion he said that he hoped to be in the lighthouse in as bad a storm as could be. He got his wish, for he was in the lighthouse and lost his life when it was beaten down during a heavy gale. It was a watchmaker who designed the foundations to hold the next lighthouse upon that spot and it exists to this day as a monument to his thought and skill. This is the Eddystone Lighthouse outside Plymouth Sound.

Not many years ago a traveling piano salesman thought he had an idea which might be turned to practical use and today that same idea has developed into one of the most efficient and practical of rotary pumps, and its manufacturers are kept busy trying to keep pace with the orders.

In the issue of Oct. 15, appeared the following news note:

"Twenty nine college professors from 25 different colleges in 19 states carry their dinner pails and earn 20 cents an hour in local industrial plants. They have forfeited their vacations that they might get more practical experience."

Suppose, for instance, that the helper referred to should happen to be one of these professors who have sacrificed their pleasure to gain practical experience and so combine practice with theory. The man to whom he offers advice may be able to say at once, by reason of years of practice, that the suggestion is not practicable, and explain very simply why. By so doing the business of engineering as a whole is benefited to that extent, for the professor is shown something he had not known before and in the course of his teaching will be able to reach and instruct a far larger number than the lone engineer who was really responsible for the change in the professor's ideas.

On the other hand the suggestion may cause the engineer, even with his years of practice, to see things in quite a new light and help him to reason out many a difficulty for himself, the better for the argument advanced in just the one case.

It was rather a long shot from watchmaker to lighthouse designer and from traveling piano salesman to pump designer, so who knows but that the man tendering advice may prove your benefactor instead of a beneficiary.

When advice is offered think it over carefully. Do not let the seeming unimportance of the person who offers it cause you to depreciate an idea that is really worthy and practical.

[*Contributed by P. J. Leaman, S. S. Texan, Puerto Mexico, Mex.*]

Remodeling a Hotel Power Plant

By W. E. Barney

SYNOPSIS—A description of some of the difficulties encountered in remodeling a hotel power plant while continuing to supply the house with power, light and heat. The work consisted not only of changing the piping and substituting a new for an old engine, but also of removing three boilers and installing new ones.

The Copley Square Hotel, in Boston, Mass., was built 20 years ago. At this time there were installed a 700-light gas meter, two 60-in. by 12-ft. horizontal return-tubular boilers, two hydraulic elevators, two high-pressure tanks 36-in. by 12-ft. double-deck type and one 6x7-ft. upright discharge tank. A central-station company furnished the lighting. Its lines came in at the top of the building and ran down through the three light shafts. The three-wire system had a double-throw switch at the top of each shaft, link fuses at each floor, and link fuses in each hallway.

When a fuse burned out the engineer clung to the seventh-story window casing with one hand and put a fuse in with the other.

These link fuses were all over the house, although the wiring was concealed, except in the basement and kitchen. Some of these circuits were connected with fuse wire instead of being wired properly. Later on an engine and belt-driven, 300-amp., 110-volt generator was installed. There was one feed pump for boilers.

When the writer took charge of this plant in 1909, three boilers were bulged and one had no brickwork under the lugs; the combustion chamber was 18 ft. deep and an 18-ft. by 24-in. smoke flue ran to a 30-in. stack. The draft was poor and the boilers were filled with scale 3/8 in. thick. There was no cleanout at the base of the chimney. Most of the piping leaked at the joints, and a siphon was kept running 24 hr. per day to keep water out of the engine room, and then it was necessary to walk on a 2-in. plank as the water, grease and oil stood about 1 in. deep.

The help left when repairs were commenced, thinking life too short to start remodeling the plant. Renewing valve seats and taking out old pipe was no small task, as, figuratively speaking, there was enough pipe for two similar hotels. The main pipes in the heating system were in fair condition. On one side I found three sizes of pipe in the main line from 4 in. down to 2 in. The returns were underground and some of the pipes were leaking, which made it difficult to get steam to the top of the building.

The first winter it was necessary to work day and night. Eventually it was decided to sell an old Corliss engine and other old machinery and install a new engine. The problem of removing the old 16-ft. split flywheel without tearing down the building had to be solved. After measuring the skylight in the sidewalk, it was evident that the wheel would clear by about 6 in. After the wheel was in the pit under the sidewalk, there was 4 in. to spare. When changing the piping and heater it was found that the exhaust pipe from the engine in use was about 6 in. under the cement floor and with no drip; it ran up 2 ft. into the heater. The drips on the engine were piped to a trap which discharged into the sewer.

A new switchboard was being put in, and the inspectors condemned the wiring, which made more work. The basement was rewired, also the kitchen and air shafts, and cabinets with plug fuses were put in all over the building. When this work was going on the electric company installed a 25-kw. meter, and by running the engine 23½ hr. per day the service was maintained uninterrupted.

Connecting the different circuits was accomplished without any inconvenience to the hotel. The first month after running the new machine, and stopping some leaks, quite a saving was made in fuel. The coal bill in January, 1909, was $826.79, but in January, 1910, was only $720.33; this was better than was expected. In March, 1910, the bulged boiler No. 3 was condemned. The blow-off pipe in No. 2 was clogged solid with scale, and troubles began to increase.

After figuring the cost of opening the building to be $1500, and to repair the boiler $1000, it was decided advisable to install new equipment, for the other two boilers had lap seams and were 19 years old, so that their pressure would have to be reduced the next year. The repair bill, therefore, would be a total loss, as the plant could not be run with less than 85 lb. pressure. It was proposed to install new boilers and elevator tanks, a new elevator pump, and cut out the old annex plant. The old boilers faced toward Blagden St., and it was planned to face the new boilers toward Exeter St. at the rear of the old boilers. Bids were called for opening the building, removing old material, shoring up the building, making foundations, which must be water-tight, and for installing three 66-in. by 16-ft. horizontal return-tubular boilers, two 5x14-ft. double-deck high-pressure tanks, one 5 and 6 by 16-ft. discharge tank, one 18 and 12 by 24-in. duplex pump, one 20 and 12 by 18-in. pump, and two feed pumps.

Several contractors refused to bid, claiming it would be impossible to comply with the plans. However, in July, 1910, the work of taking down the old pipe began and No. 1 boiler was also removed, after which the first shoring started. I-beams were placed in position and the excavating for No. 3 new boiler progressed rapidly until we struck some old piles and soon had water coming in at a rate of about 500 gal. per min. A cement partition wall was built at the rear of the old No. 3 boiler so as not to flood Nos. 1 and 2. It was found practicable to run the smoke flue at the front of the boilers instead of on top and with less initial expense.

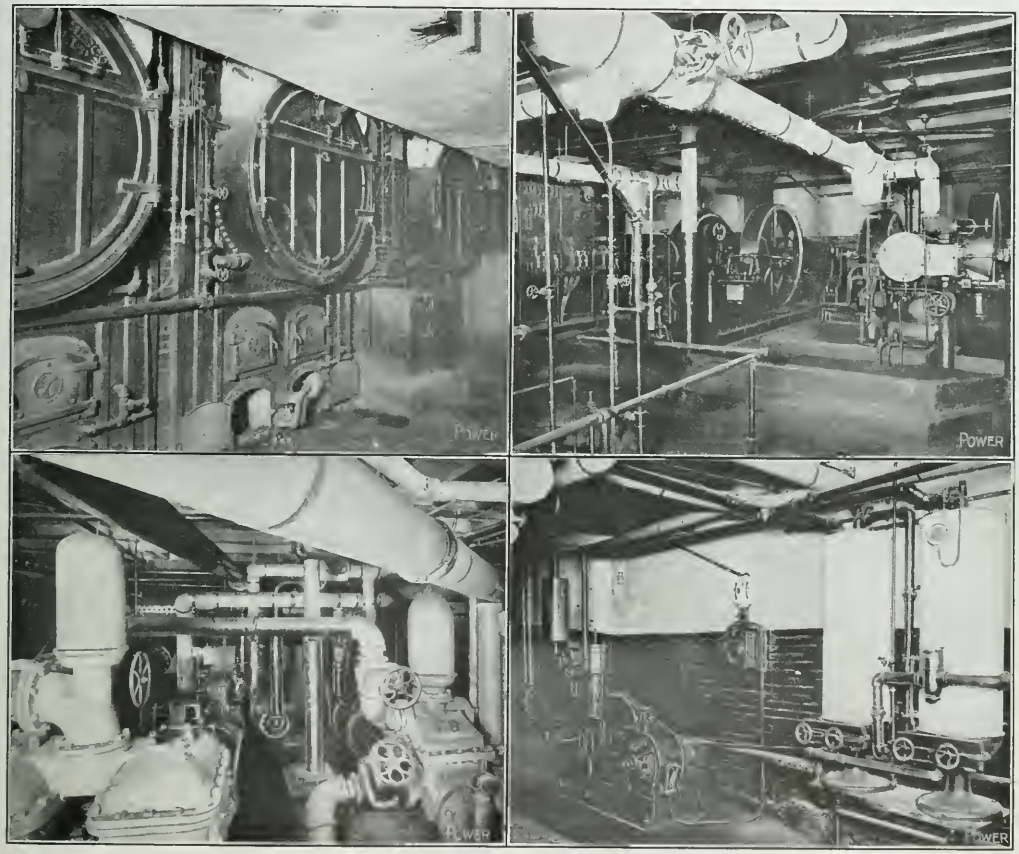
After piping the engines, the engine company wanted to equalize the machines, as the three old boilers would not make enough steam to run both engines, but with the new boiler enough steam was obtained to carry the load with a variation of 5 lb. in two 10-hr. runs. The dismantling of boilers Nos. 1 and 2 was next started, so as to shore up the building after taking down the wall to the piles; also to make a foundation for iron columns upon which 15-in. iron beams rested crosswise to hold up the building. This work had to be done before the rest of the material could be removed.

After removing the two old boilers the foundations for the new ones were put in. I-beams were placed from the inside partition wall to four piles and from these piles

too the outside building wall, going underneath the hydraulic elevators without stopping them. Then the last connection to the stack from the flue was in order. It was proposed to run the engine to furnish lights as long as we had steam and use lanterns until we finished. The size of the new flue was 36x42 in., and the work was started at midnight with a load of 100 amp., 110 lb. of steam and three gages of water, and a good fire, the elevator service was shut off, and at 5:15 a.m. the flue was connected to the chimney, the engine running all this time, the gage on the boiler showing 10 lb. and one gage of water. Although the bricks were out around the flue, the fireman was ordered to get up steam, and at 6:15 there was 95-lb. elevator service and steam for the kitchen all ready for the day's run. The brickwork was all completed by 11 a.m.

Before Nos. 1 and 2 boilers were set, the elevator service had to be removed and new tanks and pumps installed and foundations made for them. We started at midnight to take out piping, removed the elevator pump and double-deck tanks the next day, and that night built foundations for the tanks and in one week the two elevators in the hotel were running. After this the annex elevators were connected to the high-pressure tank and the annex plant shut down. All elevators were repaired, which completed the work, with the exception of a little pipe covering.

The saving in fuel was surprising, although the price of coal was 25c. per ton higher than in 1909. The fuel bill in January, 1912, was $545.82 as against $826.79 in January, 1909. With this saving of fuel and a wage of $50 per month, having let one fireman go, saving on water, oils and packings, the economy of the present plant is enough greater than before to more than pay the interest on the cost of installation.



VIEWS OF THE COPLEY SQUARE HOTEL POWER PLANT

An open competitive examination for electrical assistant will be held on Feb. 26, at the places mentioned on Circular No. 81, issued by the United States Civil Service Commission. The salary is $1080 per annum. Applicants should be familiar with the practical side of electricity as applied to telegraph, telephone and kindred engineering and should be familiar also with the equipment and methods of installation of telephones, storage batteries, motor generators, auxiliary power switchboards, telephone switchboards and with wire and radio-telegraph apparatus. Form 1312, which can be had from the Civil Service Commission, contains the requirements for applicants desiring to take this examination.

The Field for Small Steam Turbines*

By W. J. A. London and Ashley P. Peck

SYNOPSIS—Discussion of the consideration of efficiency from the commercial standpoint and the field of application where small steam turbines are especially desirable.

The authors wish at the outset to emphasize the fact that there is a marked difference between the field and requirements of the larger and the smaller turbines. In large steam-turbine work, efficiency is of paramount importance and is the basis of all designs. The machine is developed to obtain maximum efficiency under the given conditions and no reasonable expense is spared to attain this end. In other words, the designer, while naturally building his machine as cheaply as possible, must not consider expense in construction if any cheaper design would affect the efficiency in the smallest degree.

The designers of small steam turbines are confronted with an entirely different proposition. To fulfill the requirements of the market these machines must be made in quantities. Further, they must be made to sell as cheaply as possible and yet meet certain efficiency guarantees.

Sometimes a machine will be sold on its water-rate performance. At other times steam economy is of no consequence, and then the machine is obviously sold on design or price. However, it should be understood that a standard frame must fill the requirements of both.

The duties now required of small steam turbines demand at the outset absolute reliability so that efficiency must not be considered at the expense of reliability and cost.

It is a mistake to assume that the average thermal efficiency of, say, 40 to 45 per cent. which is now obtained with small turbines operating under standard conditions is the maximum possible for this type of machine. There is no reason why small machines cannot be built to approach the thermal efficiency obtained on larger machines of 65 to 70 per cent., but up to the present this efficiency has not been demanded, nor (and this is more important) has the customer been willing to pay for it; and further, we think we will be able to show that there is no necessity for such an efficiency. The theory of the steam turbine is no longer the mystery it was ten or even five years ago and it is well known that the various makes of small steam turbines are of the impulse type, as this lends itself better to compact design, which is the prime feature of all small turbines. In the impulse type (so called) the steam is expanded in a nozzle or jet and the kinetic energy of this jet is absorbed in passing one or more times through the buckets of the turbine rotor. The efficiency obtainable by a certain design is no longer guess work and the two factors governing this efficiency are, first, peripheral speed and, second, number of stages or passes of the steam through the buckets of the rotor.

Small Impulse Steam Turbines

may be divided into two general types: single stage and multi stage. In the first the steam may pass from the jets once through the buckets and thence out, or in the multi-velocity single-stage type, the steam may reverse and reënter the rotor two or more times, its velocity energy being extracted successively with each reversal.

In the multi-stage turbine the steam is expanded successively through two or more single- or multi-velocity stages, imparting to each stage a part of its energy during expansion.

It has been demonstrated that with single-stage turbines, employing the multi-velocity principle, the maximum thermal efficiency is obtainable with only two reversals; in other words, the wheel-rim velocity must be substantially one-quarter of the steam velocity. It has also been demonstrated by Prof. Stumpf and others that an efficiency of 60 to 65 per cent. can be obtained on a single wheel. A single-stage machine running noncondensing with a wheel 2 ft. in diameter running at 2500 r.p.m. employing about three or four reversals will give an efficiency of 40 per cent. The same turbine to give, say, 60 per cent. efficiency would have to have a 4.5-ft. wheel. Experience has shown that the cost of small turbines follows very closely the square of the diameter. For example, a 100-hp. machine designed for 40 per cent. efficiency would sell for approximately one-fifth the cost of an equal capacity turbine, developing 60 per cent. thermal efficiency.

Another consideration is that in the higher efficiency turbine the wheel stresses alone would be five times those in the commercial type of machine.

Again, considering the case of a multi-stage machine, the number of stages vary inversely as the square of the velocity per stage. That is, a turbine operating under duplicate conditions to those mentioned and having a thermal efficiency of 40 per cent. would have about five stages. To obtain the 60 per cent. it would require 25 stages, giving a difference in cost practically equal to that mentioned previously for the single-stage machine.

The foregoing shows that whichever way is taken and whatever type of machine is used, efficiency can only be obtained at the expense of first cost. In large turbines, why a customer should decide on a higher-priced machine with a better water rate can easily be shown. For instance, with a 5000-kw. machine having a steam consumption of 16 lb. per kw.-hr., if the consumption were reduced to 15 lb., and assuming 10 per cent. interest on the money invested, the purchaser could afford to pay $36,000 extra.

That this argument does not hold good with the smaller units is easily demonstrated. Take, for instance, a 50-kw. generator with a water rate of, say, 60 lb. per kw.-hr. One pound saving in the steam consumption of this unit should raise the price approximately 15 per cent.

These points are brought out to show that while efficiency in small turbines is often discussed by the purchaser as of vital importance, when it comes to buying the machine he is not consistent. If the price is the same and the water rate is better in one than another he will naturally favor the more efficient machine, but does he bear in mind that higher efficiency can only be obtained at the expense of reliability? In single-stage ma-

*Abstract of a paper presented at the fifth annual convention of the Association of Railway Electrical Engineers, Chicago, Oct. 21-25.

chines the larger the wheel the greater the duties on the bearings, also the increased tendency to distortion. In the multi-stage machine the more stages the more internal glands.

Considering first the application of

Small Steam Turbines for Driving Auxiliaries

in large power plants, such as exciters, boiler-feed, circulating and hotwell pumps, it is now acknowledged standard practice in uptodate power houses to run such auxiliaries by steam and to run these machines noncondensing, exhausting into feed-water heaters. A heat balance will show that in the average power house the exhaust from the auxiliaries can all be taken care of in the feed-water heater, so that the steam economy proper in the smaller unit itself is not very important. The steam turbine is therefore being adopted more and more for auxiliary drive only because of its many obvious advantages. The increased use of superheated steam and the troubles that are experienced with it in small reciprocating engines is one of the main reasons for the rapid progress made by the turbine-driven auxiliaries. Again, the growing tendency to reduce station costs by employing cheap labor necessitates apparatus that is simple and "foolproof." The turbine resembles the electric motor in its simplicity—the lubrication and attendance being about the same, whereas the marked advantage of having the source of power taken direct from the boiler instead of through any intermediate source naturally has many advantages over the electric motor, especially when the unit is placed in the basement where electrical leaks are likely to cause serious damage.

As an approved form of prime mover for alternating-current and direct-current generators for power and light in shops, etc., and for "head-end" lighting and storage-battery charging the turbine now occupies an important position. It is compact, requiring small floor space; simple in construction: requires but little attention and practically no adjustments during long periods of operation, and has an almost negligible maintenance cost. The lubrication is entirely automatic, being of the ring-oiling or forced-feed type.

Advantages over Reciprocating Engines

A marked advantage of the steam turbine over the reciprocating engine where the exhaust steam is utilized for manufacturing purposes lies in the fact that the steam turbine delivers absolutely clean steam without any cylinder oil in it as in the steam from the reciprocating engine and without the necessity and uncertainties of oil extractors in the exhaust lines.

Another feature favoring the steam turbine is its remarkable maintained efficiency as compared with reciprocating engines. The turbine will hold its original efficiency for long periods as there is no appreciable wear on the buckets or jets, therefore, no change in shape, while the reciprocating engine depends for obtaining its guaranteed water rate, upon a minimum friction loss and absolutely steam-tight valves.

That uptodate station engineers appreciate that the reliability of the auxiliary apparatus is infinitely more important than the individual unit efficiency cannot be better demonstrated than by citing several stations where steam turbines are used for driving such apparatus as circulating pumps, the speed of which is far below that of even reasonably efficient conditions.

Several modern stations are now equipped with small turbines operating at no higher speed than 1000 r.p.m. and in one instance a turbine is installed for pump work at as low a speed as 550 r.p.m. This last machine has a water rate of 65.6 lb. as against 26.7 lb. per b.hp. that would be expected from a reciprocating engine. There is obviously only one reason why turbines were installed in these stations, and that is their absolute reliability.

We are all inclined, in looking through a power house, to consider the apparatus in the following order of importance: the main generators, the boilers and, lastly, the boiler-feed pumps. We never give the matter a thought that if the boiler-feed pumps go out of commission, the whole plant would be shut down. Again, take the question of condenser pumps. If these go out of order, on a 5000-kw. machine and the machine switches over to atmosphere, the coal consumption is increased about 3½ tons per hour.

In street-railway work the duty often put upon both the main units and the whole plant is probably the most severe of any power equipment. Particularly in the electrification of tunnels we find installations where the load will vary from zero to 3000 kw. at one jump. Imagine the effect of this on the boilers. Experience has shown that the danger due to water-hammer can be practically ignored in turbine machinery. The governing of both large and small steam turbines has been so perfected during the last few years that it is undisputed that the turbine is much better suited for sudden changes of load than any other equivalent piece of apparatus.

The abuse that small turbines will stand is often enough to surprise even the designer. We remember an instance in one of the largest power houses in the country of seeing a hotwell turbine pump in a small pit below the floor. This pit was full to the top with water, turbine and pump being entirely immersed, yet the machine was running along as if nothing had happened and our attention was drawn to the fact that there was a machine underneath the level of the water only by the surging action of the water on the surface.

Comparative Steam Economy

It is still believed by many engineers that the water rates actually obtained with small turbines are much higher than those obtained with reciprocating engines of equal power and it has occurred to us that the above arguments depreciating the importance of efficiency might be taken as an acknowledgement of this fact. True, in some cases a small reciprocating engine can beat the turbine, but generally it must be borne in mind that reciprocating engine guarantees are usually given in pounds of steam per indicated horsepower. This at best is indefinite and the depreciation and consequent impairment of efficiency in a reciprocating engine are very much more rapid than in steam turbines.

The greater steam economy of the reciprocating engine is usually unquestioned, but it is obtained with a greater investment, more attention, more floor space, higher maintenance cost and less reliability than with a turbine.

Take, for instance, a railway shop where exhaust steam is required the year around for drying purposes and during the winter months for heating, the very economy of the reciprocating engine requires using live steam from

boilers at times or continuously. Maximum economy does not always mean a low water rate in the prime mover, but is an overall item.

It may be interesting to analyze a comparison between noncondensing reciprocating engine-driven and turbine-driven generators, rated at 100 kw. normal true energy suitable for a railway shop. Assume in each case a pressure at the throttle of 125 lb. and an average back pressure at the engine or turbine exhaust of 3 lb.; 60-cycle alternating current is used. The engine would be of the simple single- or four-valve type operating at 277 or 200 r.p.m. respectively, and the turbine at 3600 r.p.m.

The water rate of a new simple single-valve engine could be taken at full load as 28 lb. and of the four-valve at 24 lb. per indicated hp.hr. Correcting this for the 3-lb. back pressure and assuming a mechanical efficiency of 91 per cent. in each case gives a water rate per brake horsepower-hour of 32.4 lb. and 28 lb. respectively. With an operating power factor of 80 per cent., and assuming a full-load generator efficiency overall, including friction and windage of 93 per cent. and 91.6 per cent. respectively, we have an approximate water rate per kilowatt-hour for the single-valve of 46.6 lb. and for the four-valve of 41 lb.

The turbine water rate per brake horsepower-hour would be 31.75 lb. at free atmospheric exhaust and with 3 lb. back pressure, 34.2 lb.

A 125-kv.-a., two-pole, 36,000-r.p.m. alternating-current turbo-alternator of good design will test to 88 per cent. efficiency at full load and 80 per cent. power factor. This gives a water rate per kilowatt-hour for the unit of 52.2 lb.

In this typical comparison, the single-valve reciprocating engine when new and operating under similar conditions to a steam turbine, will develop at full load an overall rated efficiency of 5.6 lb. per kw.-hr. better than the turbine, and the four-valve water rate will exceed that of a turbine by approximately 11.2 lb. per kw.-hr. at full load.

This saving would be important were there no uses for the exhaust steam, as there are in railway-shop practice, for the exhaust from the prime movers but rarely goes to atmosphere.

In boiler-feed pump work it is difficult to obtain information bearing on the actual water rates obtained with reciprocating pumps. The best at our disposal is the series of tests that were carefully carried out on board the scout cruisers "Birmingham," "Chester" and "Salem," which are tabulated below, and in the same table is shown the figures obtainable from turbine pumps, which show an average advantage in favor of the turbine pump of about 31.8 per cent.

WATER RATES OF SMALL TURBINES

	Steam Press., lb.	Back Press., lb.	Gal. per min.	Head, ft.	(Recip. Pumps) W.H.P. Water rate, lb.	(Turbine Pumps) W.H.P. Water rate, lb.	Improvement in favor of turbines per cent.
Birmingham..	183	6	329	488	83	61 8	25.5
Salem.....	203	6	193	690	91 8	61.2	33.4
Chester.....	187	6.7	219	610	101.0	64	36.6

With reference to the general subject of steam consumption and the statements sometimes made that the small turbine is passing, say, twice as much steam as it should, it may be interesting to review the principle governing steam consumption in small turbines with special application to Napier's simple formula:

$$W = \frac{PA}{70}$$

where

W = Weight of steam per second, lb.;
P = Absolute steam pressure, lb.;
A = Area of orifice, sq.in.;

for the flow of steam through nozzles cannot be used to greater commercial advantage than it is at present. This formula has been proved so many times to be approximately correct that it is a pity it is not more extensively used to compute the steam consumption. Most small turbines now operate with a terminal pressure at the jet of about 0.58 of the initial pressure, so that this formula can be readily applied to any machine and the steam consumption determined by placing a gage in the steam ring.

The maker could be called upon to give the number and size of the jets and in this way an instantaneous reading could be taken showing the amount of steam passing at any one time. If this were done, less claims would be made that a turbine is passing more steam than the makers claim for it.

By a slight modification of the constant 70 in Napier's formula for various jets, figures can be obtained as accurate as is possible by actual measurement. In a series of tests carried out on a certain machine, in seven readings with a ring pressure of from 40 to 150 lb., the maximum discrepancy between the calculated and the actual results was 1.3 per cent. and the mean over all the readings, 0.457 per cent.

The actual figures obtainable on test and those calculated are as follows:

Napier's Formula	Actual Tests	Per cent. Variation
2028	2043.6	0 8
1264	1248.0	1.3
1935	1934 0	0.0
2625	2638 0	0.5
1905	1906 0	0.0
3047	3066 0	0.6
2272	2272 0	0.0
		3.2
	Average...	0.457

Since this paper was prepared with special reference to railway-shop work, the subject of condensing steam turbines has been touched on but lightly, as we understand that almost universally power equipments for railway shops are operating noncondensing in view of the many uses for the exhaust steam.

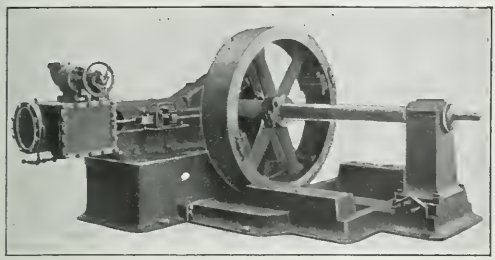
The steam turbine, like the air brake, the steel railway coach, the locomotive superheater and other improvements of recent years in railroad practice, has succeeded in breaking down the traditional conservatism which marks "something new" in all mechanical undertakings, and this is not surprising when it is recalled that the first steam engine, dating back to a century before the Christian Era, was nothing more or less than a steam turbine. The rapid introduction and commercial success of the large power turbine in common use today, rendered the introduction of the small turbine but natural in every way, and as a substitute for a reciprocating engine it has an assured and prominent position.

❖

There are two causes for a belt not running true upon properly built pulleys mounted upon correctly aligned shafting. The belt may not have been made straight in the first place, or the ends may not have been joined squarely. Otherwise there may have been a lack of uniformity in the texture of the hides from which the belt was made; belly leather toward one edge and flank leather toward the other, and the two stretching unequally.

Redesigned Brownell Engine

The Brownell side-crank high-speed steam engine, built by the Brownell Co., Dayton, Ohio, has been redesigned to embody some new features. For greater stiffness extra metal and internal ribs have been provided in the frame, which is cast in one piece. There is a chamber between the guides and the cylinder into which oil and water from the stuffing-boxes drain and are conveyed to a pan in the base of the frame from which they can be drawn off at will, filtered and the oil used again.



Redesigned Brownell Engine

The main babbitted bearing is made in four parts: The bottom piece is fitted to a bored seat, with tongue and groove to prevent end motion. The side pieces are adjusted by wedges at each end, bearing against distance pieces and controlled by bolts through the cap. The top piece is adjusted by liners and held down by jamb screws through the cap.

Oil grooves in the side pieces start from the upper edge but do not extend quite to the lower edge so that they must be filled before oil will be carried by the shaft to the reservoir formed by the beveled edge of the quarter box and from which the grooves in the bottom are supplied. All bearing parts can be removed without lifting out the shaft.

The solid-end connecting-rod has split boxes with wedge adjustment. The crosshead pin is held in place by a flange and four clamp bolts and is adjusted by two distance screws passing through the flange and bearing on the crosshead.

The flywheel, eccentric and governor are split so as to be easily removable.

A forged-steel valve-rod guide bar is carried in brackets and runs in a flood of oil supplied from a pocket filled by the splash system, as shown by the illustration.

A Sweet type double-ported valve, but designed without a center web, to give lightness and freedom from casting strains, is covered by a flat plate held from endwise motion by adjusting screws so that the lead can be varied between the ends of the cylinder, giving a wide range in controlling the events of the stroke. The plate is held against the valve by flat springs, bearing on the steam-chest cover, thus providing means of relief from excess cylinder pressure.

In addition, new designs have been made for an open-frame type, the same as the rolling-mill frame type of Corliss engine, with throttling or automatic governors.

Simple Approximate Metric Conversions

By Albert A. Cary

SYNOPSIS—Simple rules for quickly converting metric measurements to those of the English system with approximate accuracy so that one used to thinking only in the latter units can quickly gain an appreciation of the value of the less familiar figures. Most of the calculations can be done mentally.

Recently the writer was professionally engaged on the European continent for the greater part of a year, where the metric system was in universal use. At first, he experienced the general feeling of vagueness when matters were presented to him in metric units, that most all do who have only used this system occasionally at home, with a conversion table before them.

No one can appreciate the fine points of this system until he can think in metric units, without regard to the clumsy units commonly used in this country, and without the necessity of making conversions. Unfortunately, for a time, one from "the States," has to convert the metric units into the system he is acquainted with, to size up their values comprehensively, and the more exactly he attempts to do this the slower he is in becoming intimate with the metric system, especially if he has to refer to reference tables frequently.

As the writer's experience in this direction may be of value to others he offers here the means he worked out for arriving quickly (and in most cases mentally) at rough approximations, which were sufficiently close to serve ordinary purposes.

Our money system fortunately educates the European visitor from this country in the elementary steps of the metric system, so when he reaches the countries using the metric system he will be sure to remember that

10 mills (milli) make one cent
10 cents (centi) make one dime
10 dimes (deci) make one unit

which unit, in our money, is the dollar.

In the metric system, the unit may be one of length (the meter);—of weight (the gram);—or capacity (the liter) and fractional parts or multiples are indicated by placing a prefix before the unit.

The prefixes derived from the Latin numerals always indicate a fractional part as

Milli	$\frac{1}{1000}$
Centi	$\frac{1}{100}$
Deci	$\frac{1}{10}$

the same as with United States money, while the prefixes taken from the Greek numerals indicate multiples. Thus

Deca, which indicates multiplied by 10
Hecto, which indicates multiplied by 100
Kilo, which indicates multiplied by 1000

That a kilowatt means a thousand watts is familiar, so all one need remember in addition, are deca and hecto.

The Rule of Ten per Cent.

Taking the units themselves, it is surprising how many are about *10 per cent. more than our own units.*

Weights

Going to the various stores one finds that the very common unit of weight in Europe is the half kilogram, which is practically 10 per cent. more than our pound.

The kilogram then, is 10 per cent. more than 2 lb., so, to convert kilograms to pounds, simply multiply by 2 and add 10 per cent.

If the weight is expressed in grams, multiply by 2 and add 10 per cent, as before, but as a gram is $\frac{1}{1000}$ of a kilogram, move the decimal point three places to the left in the final result, even if this process does prefix a number of cyphers. It is easy to multiply this last result by 7000 (7000 grains = 1 pound avoirdupois), to obtain it in grains if it is a small weight.

For example, take 85 kg.

$$85 \times 2 = 170 + 17 = 187\ lb.$$

(the error here is only 0.4 lb.) again, take 60 grams

$$60 \times 2 = 120 + 12 = 132$$

and moving the decimal point three places to the left gives 0.132 lb.

$$0.132\ lb. \times 7000 = 924\ grains$$

(the error in this case is only 2 grains).

It may also be remembered that the metric ton, which is 1000 kg. (or 2204.62 lb.), is practically the same as our long ton of 2240 lb.

Lengths

The unit of length is the meter with which an added 10 per cent. may again be used, with a very small error in the results obtained.

The meter is practically 10 per cent. more than a yard.

The use of a thin pocket rule one meter long, which can be purchased anywhere on the continent, will furnish the easiest method of converting short distances from the meter and its fractions into feet and inches; these two systems being found on its opposite sides. Such a rule measures only 8 in. long, $\frac{3}{8}$ in. thick by $\frac{7}{8}$ in. wide, when closed. It has six swing joints, is made of wood, is very light and can be easily carried in the pocket.

To return to the method of calculation; with a measurement given in meters, merely add 10 per cent. which converts it into yards. This result multiplied by 3 gives the number of feet.

For example, take 42 meters

$$42 + 4.2 = 46.2\ yd.$$
$$46.2 \times 3 = 138.6\ ft.$$

(Figured exactly, this should be 137.795 ft.)

As stated before, any fraction or any multiple of a meter is calculated the same way by taking the dimension given as though it were in meters and afterward placing the decimal in its proper position, the same as in calculating U. S. money. Thus, for 60 cm., proceed as follows:

$$60 + 6 = 66$$

As there are 100 cm. to the meter, point off two places to the left, thus obtaining 0.66 yd. or 1.98 ft. (exactly, this would be 1.9685 ft.).

Surfaces

The unit of surface is the square meter, and for its conversion to English units the 10 per cent. rule is still applicable, but as a square is of two dimensions (length and breadth), two 10 per cents. must be used to obtain square yards, and for square feet, the square of 3, or 9, is the multiplier.

Applying the rule, 42 sq.m. is converted thus:

$$42 + 4.2 + 4.2 = 50.4\ sq.yd.$$
$$50.4 \times 9 = 453.6\ sq.ft.$$

(exactly, this would be 152.08 sq.ft.).

For all fractions or multiplies of the square meter, one can proceed as before, using the expression at the start as though it were in square meters, but in pointing off the final results, it must be remembered that all these smaller or larger expressions must be squared, for while 3 ft. = 1 yd., $3 \times 3 = 9$ sq.ft. = 1 sq.yd. Thus, 1 sq.m. is composed of $100 \times 100 = 10{,}000$ sq.cm., or $10 \times 10 = 100$ sq.dcm., etc. In other words, the square being of two dimensions, one must point off twice as many decimal places as if he were using the simple linear meter.

Volumes

The unit of volume is the cubic meter, to which the 10 per cent. rule also applies, but as the volume has three dimensions (length, breadth and thickness), three 10 per cents. must be used. Also, in converting cubic yards into cubic feet, one must multiply by the cube of 3, or 27.

To convert 36 cu.m. to cubic yards, proceed, by the rule, as follows:

$$36 + 3.6 + 3.6 + 3.6 = 46.8\ cu.yd.$$
$$46.8 \times 27 = 1263.6\ cu.ft.$$

(Figured exactly, it would be 1271.32 cu.ft.)

It must be remembered that in a cubic meter (sometimes called a stere) there are

$$100 \times 100 \times 100 = 1{,}000{,}000\ cu.dcm.$$

Therefore, in making calculations for fractions or multiples of the cubic meter, by this simple rule, one must point off three times as many decimal places as for straight linear calculations, on account of dealing with a volume which has three dimensions.

Capacity

The unit of capacity is the liter, and 1000 liters equal the volume of one cubic meter. One kilogram of pure water at its maximum density (39 deg. F.) under normal atmospheric pressure (29.7 in. of mercury) occupies the volume of one liter.

For rough approximation the 10 per cent. excess rule can be used to gain an idea of the volume occupied by any number of liters, but a liter is more nearly 5 per cent. greater than a quart (liquid measure).

Thus, given 40 liters, the calculation is

$$40 + \tfrac{4}{2} = 42\ quarts$$

(exactly, this figure should be 42.267 quarts).

In figuring fractions or multiples of the liter, the decimals are pointed off the same as for lengths, as 100 centiliters or 10 deciliters equals one liter and one kiloliter equals 1000 liters.

These simple 10 per cent. rules are easily remembered and equip one to use the metric system without conversion tables with their many varied constants or multipliers.

A few other useful rules involve the figures 0.6, 1.6 and 16.

For a rough approximation of 100 km., multiply by 0.6, which gives 60 miles. In reality, it is 62.137 miles. A closer calculation can be made after multiplying by 0.6, by adding to this result one-half of the product, but

with the decimal point moved one place to the left thus:

$$100 \times 0.6 = 60$$

and half of 60 is 30, which, by moving the decimal point, becomes 3, and, added to 60 gives 63 miles.

To convert miles into kilometers, multiply by 1.6.

$$100\ miles \times 1.6 = 160\ km.$$

(To be exact, this should be 160.935 km.).

There are approximately 16 cu.cm. to the cubic inch; therefore divide cubic centimeters by 16 to get cubic inches. Usually it is quicker to divide twice by 4 ($4 \times 4 = 16$).

Thus, in 100 cu.cm. there are

$$\tfrac{100}{4} = 25 \text{ and } \tfrac{25}{4} = 6.25\ cu.in.$$

(Exactly, this should be 6.1023 cu.in.).

Per contra—in 100 cu.in. there are

$$100 \times 16 = 1600\ cu.cm.$$

(Exactly, this should be 1638.7 cu.cm.).

A number of conversions not admitting of such simple rules the writer noted on the back of a 6-in. slide-rule, which proved constantly useful. These included steam-gage readings, which are commonly indicated in kilograms per square centimeter:

14.223 lb. per sq.in. = 1 kg. per sq.c.
0.070307 kg. per sq.c. = 1 lb. per sq.in.

The rate of evaporation in a boiler is usually expressed in kilograms per square meter so, to convert this reading into pounds per square foot, multiply by 0.2048.

Dividing by 5 gives a close approximation. Thus, 20 kg. per sq.m. equals

$$\tfrac{20}{5} = 4\ lb.\ per\ sq.ft.$$

(Exactly, this will be 4.0962 lb. per sq.ft.).

To convert pounds per square foot into kilograms per square meter, multiply by 4.883. Using 5 for a multiplier, gives a close approximation, as with

$$3\ lb.\ per\ sq.ft. \times 5 = 15\ kg.\ per\ sq.m.$$

(Instead of the exact 14.647).

Calories per kilogram can be converted into British thermal units per pound by multiplying by 1.8 or equally exactly by doubling the calories per kilogram, and then subtracting 10 per cent. of this amount. Thus,

$$8080\ calories\ per\ kg. \times 2 = 16{,}160$$
$$16{,}160 \times 10\ per\ cent. = 1616$$
$$16{,}160 - 1616 = 14.544\ B.t.u.\ per\ lb.$$

The reverse calculation is not quite so simple, as the heat units per pound must be multiplied by 0.556 to obtain the calories per kilogram.

Thermometer Scales

The simplest method for converting Centigrade to Fahrenheit degrees is the following, but the writer does not claim originality in the fundamental principle on which it is based.

The two fixed standards by which thermometers are calibrated are, the freezing and boiling points of water. On the Fahrenheit scale they are 212 and 32 deg., respectively, and on the Centigrade scale 100 and 0 deg. Thus there are 180 divisions (or degrees) between these two critical temperatures on the Fahrenheit scale and only 100 on the Centigrade. Doubling Centigrade degrees to obtain Fahrenheit gives a product 10 per cent. too large so, multiplying by 2 and subtracting 10 per cent., gives again a simple method of conversion. Thus:

$$100 \times 2 = 200 - 20 = 180$$

Unfortunately, the Fahrenheit zero is 32 deg. below the freezing point, or the zero on the Centigrade scale, so 32 deg. must always be added to obtain degrees Fahrenheit, thus:

$$180 + 32 = 212\ deg.$$

By memorizing a few more or less fixed points and their equivalents, the writer found he could sense the value of the Centigrade readings without attempting even this simple method of conversion.

0 deg. C. = 32 deg. F.—The freezing point of water
4 deg. C. = 39 deg. F.—Temperature of water at its greatest density
15 deg. C. = 60 deg. F.—(This should be 15.6 deg. C.) Average atmospheric temperature
38 deg. C. = 100 deg. F.
100 deg. C. = 212 deg. F.—The boiling point of water

The following table sums up in compact form, for easy reference, the various rules hereinbefore given:

Dimensions etc.	Unit Used	Converted to	Rule
Weight	Kilogram	Pounds	Multiply by 2 then add 10 per cent.
Lengths	Meter	Feet	Add 10 per cent. then multiply by 3
Surfaces	Square Meter	Square Feet	Add two 10 per cents, then multiply by 9
Volumes	Cubic Meter	Cubic Feet	Add three 10 per cents, then multiply by 27
Capacity	Liter	Quarts	Add one-half of 10 per cent. (or 5 per cent.)
Temperature	Centigrade	Fahrenheit	Multiply by 2; subtract 10 per cent, then add 32
Heat	Calories per Kilogram	B.t.u. per pound	Multiply by 2 then subtract 10 per cent.
Heat, B.t.u. per lb.	Calories per kilogram		Multiply by 0.556 (or divide by 6 and then by 3)
Pressures	Kilograms per square centimeter	Pounds per square inch	Multiply by 14.223 or divide by 0.07
Pressures	Pounds per square inch	Kilograms per square centimeter	Multiply by 0.07
Evaporation	Kilograms per square meter	Pounds per square foot	Divide by 5
Evaporation	Pounds per square foot	Kilograms per square meter	Multiply by 5
Distance	Kilometers	Miles	Multiply by 0.6 and add 5 per cent. of the product
Distance	Miles	Kilometers	Multiply by 1.6
Capacity	Cubic centimeters	Cubic inches	Divide by 16 (or by 4 twice)
Capacity	Cubic inches	Cubic centimeters	Multiply by 16

As most of the results obtained will be in error, to the extent already explained, where exact results are needed, one should refer to conversion tables, such as those in Kent's or Suplee's engineer's pocket books, Hering's "Conversion Tables," or to the work issued by the Hartford Steam Boiler Inspection & Insurance Co. on the metric system.

A table of prefixes and their values as used in the metric system, taken from Hering's "Conversion Tables," follows:

PREFIXES USED IN THE METRIC SYSTEM

Micro-	0.000 001	or 10^{-6}
Milli-	0 001	or 10^{-3}
Centi-	0 01	or 10^{-2}
Deci-	0 1	or 10^{-1}
Deca- or Deka-	10	or 10^{1}
Hecto- or Hekto-	100	or 10^{2}
Kilo-	1 000	or 10^{3}
Myria-	10 000	or 10^{4}
Mega-	1000 000	or 10^{6}

Thus one millimeter equals 0.001 meter, or one kilometer equals 1000 meters.

Quitetite Reducing Valve

This reducing valve is manufactured in this country by the Auld Co., 1253 North 12th St., Philadelphia, Penn. The valve has been designed to give a positive closing control and to obviate any tendency of the reduced pressure to creep past the point at which it is set.

The controlling area of the valve is equal to six times the area of the back of the valve and the danger of an accumulation of pressure on the reduced pressure side is eliminated. The valve is designed to maintain a constant reduced pressure even with great fluctuation in the initial pressure.

Referring to Fig. 1, the high-pressure steam enters through the inlet and acts between the valve *D* and piston *F*, Fig. 2, which are of the same area and therefore in equilibrium on the high-pressure side. A reduction of the pressure is obtained by screwing up the adjusting nut *A*, Fig. 2, until the pointer *B* on the spring bolt is opposite the figure representing the reduced pressure required. Acting through the lever *C* the extension of the spring opens the valve *D*, Fig. 2, and passes steam at a reduced pressure to the outlet side. When the pressure of this reduced steam tends to rise above that required, it closes the valve by acting on the back of the valve *D* and chamber *E*. When the pressure tends to fall the tension of the spring overcomes the force holding the valve closed and opens the valve, allowing it to admit more steam to the low-pressure side; in this way the reduced pressure is kept constant.

A flexible-rubber composition diaphragm *G* is fitted at the lower end of the valve body which makes a frictionless steam-tight packing between the stationary and movable lower half of the valve. This diaphragm is protected from contact with steam by water of condensation, which

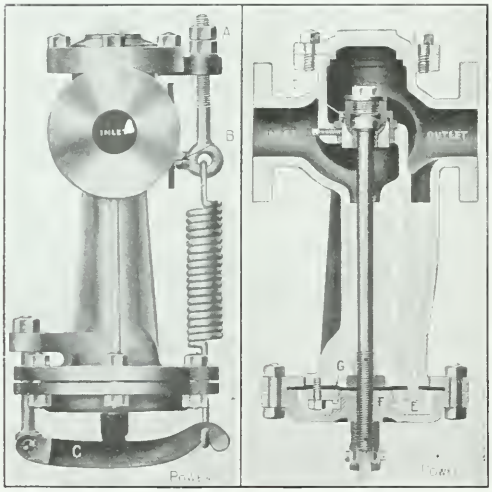


Fig. 1. Spring and Lever

Fig. 2. Section through Valve

collects in the lower part of the valve and keeps the diaphragm cool.

The valve is made in sizes from ½ in. upward with screwed or flange connections. The sizes above 2 in. have standard flanged ends. They are suitable for use wherever it is desired to reduce the steam from a higher to a lower pressure. The valve is designed to maintain a reduced pressure of from 2 to 3 lb., or other very low pressures on the outlet side, while the boiler pressure may be as high as 250 lb. per sq.in.

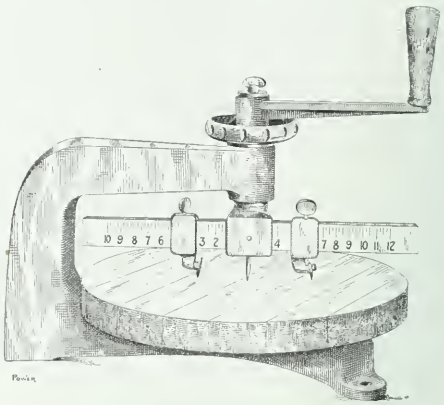
⁂

Orders have been received in the Crewe Railway Works, England, for a large number of locomotives which will be the most powerful in that country. They are to be of great size, and are intended especially to draw very heavy loads at great speeds. The locomotives will be of the four-cylinder type, the cylinders all acting independently of one another. The distribution of steam will be by a new piston valve.

Stewart Gasket Cutter

The accompanying illustration shows a gasket cutter for cutting sheet asbestos, fiber cloth, wire insertion, copper, lead or other metallic packings to any size from 1½ in. up to 12 in. in diameter.

The frame is cast iron, and has a hard maple table secured to it by screws. The crank has a square opening which fits over the vertical spindle with a ½-in. space between the top of the spindle and the top of the crank, to allow for adjusting the thumb feed-regulating screw.



Stewart Gasket Cutter

The force-feed handwheel may be used on soft packings for feeding the cutters downward. The carrier bar is graduated in inches, and any required size of gasket can be obtained by adjusting the cutters to the scale. The cutters are tool steel, and are dished on the inner side, concave on the outer and set at a slight angle.

In cutting fiber or other hard material the thumbscrew may be adjusted by a quarter turn so that the feed is automatically regulated. The carrier bar moves down ⅛ to ½ turn, to one revolution as desired.

This machine is made by L. R. Stewart, 70 East Thirty-first St., Chicago, Ill.

⁂

The Salting of Mr. Fresh

BY R. O. RICHARDS

Swaggering into the presence of Podgers, the master mechanic, he said:

"My name is Fresh—Joe Fresh. I'm the guy that put poles on tadpoles, and I'm from the firm that smears butter on butterflies."

"You're from Butterfly & Co., the machinists?" queried Podgers.

"Yaas. Come to do surgery on your sick engine."

"Sit down, Mr. Fresh," said Podgers quietly, "and I'll state the symptoms. The engine is really not what you may call ill; I'd diagnose her case as plain laziness. She enjoys too many luxuries, and I want you to remove some of them. I want you to take away the pillow from her pillow block, the rocker from her rocker-arm, the bed from her bedplate, and the pipe from her exhaust. And I think she would work better if you removed the cap from her head, the jacket from her cylinder, the slippers from her crosshead, and clothe her in more workmanlike overalls and jumper. Also, you may remove the banjo from her governor, shoo the fly from the flywheel, take the dyn from the dynamo, and—"

But here Podgers saw that his visitor was beyond hearing—poor Mr. Fresh had collapsed.

ELECTRICAL DEPARTMENT

Drying Out Electrical Machinery

By Francis H. Davies

The circumstances under which a thorough drying out of electrical machinery becomes necessary are comparatively rare, but when the need does arise, it is generally urgent, and should be carried out in an expeditious and efficient manner. Considerable experience has been gained on this subject, and it is apparent from the results obtained after the Seine floods in Paris and upon other occasions, that most of the methods generally employed are good provided they are thoroughly carried out. Failure is generally attributed to the method, but more often it is due to insufficient time being allowed or to the neglect of certain precautions. Circumstances will materially affect the amount of damage done by immersion: that is, much will depend upon the quality of insulation, the dirtiness of the water and to some extent the time the machinery has been immersed.

It is important that when the water subsides or the machine has been lifted out of it, the process of drying be commenced without delay. If this be done the drying-out process will require much less time and there will be a better chance of success. If, on the other hand, the machine is left exposed to the air in a wet condition for a week or two, it has been found that in many cases no amount of drying will be effectual, owing to the insulation having been destroyed. Generally speaking, flood water is dirty, containing mud and decayed vegetable matter, and when to this is added the oil which is always present around machinery, and possibly the acid from neighboring accumulators, it is evident that a thorough washing is an essential preliminary. This should be carried out at once before the mud has had time to dry, and it can scarcely be overdone. If there has been much oil about and it is found to have worked into the windings, benzoline or gasoline will be found effective; and should there be signs of acid corrosion, a weak bath of potash followed by a thorough cleansing with pure water is a good treatment.

These preliminaries having been completed, attention must be at once turned to the application of heat for drying. There are many methods of doing this, the choice depending upon their relative convenience. Coke fires, open or closed, steam heat and the passing of current through the windings may be used singly or in conjunction. If the machinery is small it may be taken apart and baked in the ordinary drying oven. This is the better course to take with field coils of all sizes and small armatures, but the proposition is rather a different one to that for which a drying oven is ordinarily used as the coils will be excessively wet and may require higher temperatures and a longer time. Ovens of this sort are operated on two systems—by heat alone at a temperature of about 200 deg. F., or by heat and a partial vacuum which tends to draw out the moisture. In the second case the heat required is lower, the effect of a temperature of 200 deg. F. being about equal to 240 deg. where heat alone is used. In either case it may be necessary to extend the baking over several days, but it is impossible to speak definitely upon this point as circumstances vary so considerably and machines themselves are widely different in the effect that immersion produces.

Insulation tests should be made at intervals, and it will generally be found that while the insulation resistance rises fairly rapidly to thousands of ohms, progress is slower toward the end. When it is considered that the amount of water which has to be drawn out of a large machine after it is externally dry may amount to several gallons, it is clear that the operation may be lengthy.

If a machine is too large to take to the ovens it must be dried where it is and a certain amount of ingenuity is often necessary to devise satisfactory methods. The chief agents available are the coke fire (preferably inclosed), the steam radiator and electric current. The machine should be dismantled to some extent so as to allow the hot air to penetrate easily to all parts, and it has been found a good plan to rotate the armature at about its normal speed so as to throw out some of the water by centrifugal action. In doing this it is important to make sure that no potential is set up as the insulation might be broken down permanently. Hot air generated by a closed stove is preferable to the direct action of an open fire as the acid fumes of the latter are deleterious. To dry a machine in this way it should be entirely inclosed by a wooden structure, the joints of which are covered with stout paper to prevent leakage. The stove should also be inclosed with a flue pipe leading outside to the air, and if one or more small fans are placed in the right position, proper circulation (which is very helpful in drying) can be kept up. The same principal is applicable where steam radiators are used, but if timber is not handy an effective substitute will be found in a stout tarpaulin carefully arranged so as to prevent leakage. A temperature of about 180 deg. F. should be aimed at, and it may be necessary to maintain this for several days.

Electrical drying by means of a current generated in or passed through the windings is usually a longer operation, but at times it may be the only method available. It is seldom applicable at the start, because it may cause damage by electrolysis if not by actual breaking down of the insulation. Until the latter begins to test out at a fairly high value currents at low voltage must be used, and according to the nature of the machinery these will be attained in different ways. Armatures may be dried by being short-circuited at the brushes and run slowly with a weak field. As the insulation improves, both the field and the speed may be increased until the highest safe temperature is attained. The danger point is about 300 deg. F., at which heat cotton commences to discolor. The commutator often presents special difficulty and it may become necessary to take it off and dry in an oven. If the insulation remains low obstinately this is generally the place to look for the trouble. Should it be preferred to pass current through the machine from an external source the armature should be kept rotating slow-

ly as this will tend to more uniform drying, particularly of the commutator.

Transformers are difficult to dry out when thoroughly wetted, owing to the depth of their windings, and to assist matters it is well to remove any external insulating wrappings. A low voltage current should then be passed through the high potential coils, the low potential side being short-circuited.

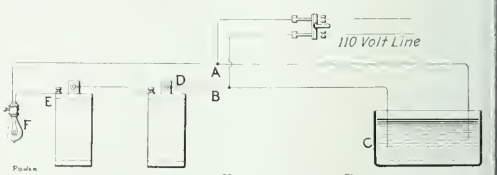
Generally speaking, electric plants do not suffer from excessive wetting to the extent that would be anticipated even if entirely submerged for weeks. Remarkable proof of this was found in the case of the Seine floods of Paris in 1910, where machines and cables which were then submerged for several weeks and apparently ruined are at work today. One particularly striking fact is that batteries of accumulators were quite uninjured by several hours' immersion, the higher specific gravity of the acid causing it to remain in the cells with very little dilution. There also does not appear to have been any damage by reason of the battery discharging through the water, as in one instance a battery which was covered for several hours by 10 ft. of water was found capable of giving a long discharge after the flood had subsided.

Modern underground cables if properly installed are fairly proof against damage by water. A good lead-covered impregnated paper-insulated cable if well jointed with water-tight boxes will suffer no harm, and should the water find its way in, it is usually only necessary to cut off a few yards at the end where the water will be found to have penetrated in between the core and its immediate insulation. Rubber cables unprovided with a lead sheath will not stand so well unless they are thoroughly waterproofed and quite new. The insulation of an old rubber cable is quickly destroyed by water and it cannot be repaired. Telephone underground cables of the dry-core or air-space paper-insulated type are very susceptible to water, and, while the sheath may protect them indefinitely, the slightest damp will quickly put them out of action. In an extreme case it is necessary to take off the lead sheath, dry the cores in an oven and then resheath the cable, but in the ordinary course the application of a desiccating machine to the dry end of the cable will suffice. This machine consists of a gasoline motor or hand-driven air compressor, air receiver and four cast-iron cylinders containing bags of calcium chloride, the whole being mounted on a truck so as to render it portable. A special connection is made to the cable, and air is pumped in at a pressure up to 30 lb. per sq.in. In passing from the compressor it flows through the calcium-chloride cylinders and emerges from them in a perfectly dry condition. It then flows along the cable through the air spaces between the wires, and emerging at the wet end carries with it the entrained moisture. The operation may take several hours or even days in a bad case.

Recharging Dry Batteries

No doubt many readers of POWER have had dry batteries which after a time have lost their strength and were thrown away as useless with the belief that they were beyond repair. Dry batteries will not only give out due to excessive use but also from standing idle upon the shelf when not in use. When batteries are not corroded badly at the connections or the zinc shell eaten away they can frequently be recharged and made to give service for some time.

The first thing to do when batteries have given out is to look at the connections which may have become broken or corroded. If the circuit seems to be all right an examination should be made of the cells to see if the zinc shells are sound and in good condition. If the cells are not eaten through, the batteries may be connected in a direct-current circuit as shown in the sketch, the lamp acting as a resistance. Having arranged the batteries and the lamp first allow the ends of the two wires *A* and *B* to be submerged in the jar *C* containing water in which a



CONNECTIONS FOR RECHARGING DRY CELLS

little salammoniac has been dissolved. It will be noticed that one wire will give off a greater number of bubbles than the other; this wire should be connected to the carbon terminal *D* of the batteries the other wire *A* to the lamp *F*. Having made the proper connections and removed the wires from the jar of water the current is allowed to pass through the cells for half an hour. It will be found helpful if a hole is melted through the wax of each cell and the latter submerged in water for a few minutes before the current is passed through it. When removing from the water the hole should be sealed by remelting the wax.

MARTIN MCGERRY.

Holley, N. Y.

Reversed Polarity

Mr. Gibbeney's inquiry in the Jan. 14 issue does not state what kind of load was being carried at the time but I presume it was a motor load. Due to the sudden slowing down of the engine the motors failed to respond to the sudden change of speed. Had the engine slowed down gradually the motors would have responded and also slowed down, but due to the momentum of the shafting and machines which they were driving they were driven as generators feeding current back through the line and series winding to the generator. The shunt field had become so weak by that time it was neutralized and the polarity reversed.

That no trouble was noticed on speeding up the engine again except the reversal of the polarity was due to the current being so weak by that time in the release magnets of the starting boxes that they had let go and the starting arm had gone to the off position, thus opening the line between generator and motor. Had they not done so there would have been a short-circuit which would have blown the fuses on the motors, or blown the circuit breakers.

It will be noticed on shutting down a direct-current motor that there is sometimes quite an interval of time after the main switch is pulled before the motor stops, due to the momentum of the shafting or machines which are being driven.

Also the arm on the starting box stays up against the release magnet until the motor is almost to a standstill, which shows that the motor is acting as a generator and continues as such until it fails to generate sufficient current to hold the starting arm in place when the spring on the arm throws it to the off position.

LEON L. POLLARD.

Fairfield, Maine.

In all probability Mr. Gibbeney has one or more motors on the line pulling machinery with heavy rotating parts. When the governor on the engine was unlatched the momentum of these parts kept their driving motors running long enough to generate enough current to reverse the polarity of the generator.

If he had raised the voltage and brought these motors up to speed with the polarity reversed, unlatched the governor again suddenly for a moment, tripped the machine circuit-breaker, and brought the engine back to speed, I think he would have found the polarity correct again.

EARL PAGETT.

Coffeyville, Kan.

The reversal of polarity was probably indirectly caused by a temporary short or overload, which unlatched the governor and in turn slowed down the engine.

In the meantime moderate to heavy currents were flowing through the armature circuit and a minimum current was passing through the shunt field by reason of the lower speed.

Hence the armature reaction neutralized and reversed the already weak field, and the latter in turn reacted on the slow-moving armature coils and created a reversed electromotive force which reached normal when the speed reached the ordinary limit.

BEN DAWSON.

Cedar Rapids, Iowa.

[Replies similar to those of Mr. Pollard and Mr. Pagett were received from William Hirst, Trenton, N. J.; C. W. Bend, Cincinnati, Ohio, and J. L. Birchell, of Baltimore, Md.—EDITOR.]

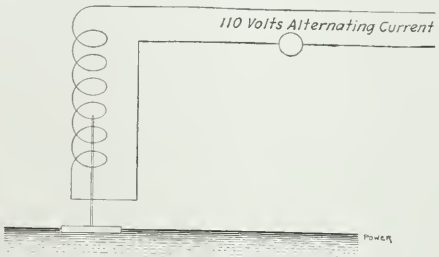
Water Level Indicator

Many different schemes are in use to indicate the height of water in tanks and reservoirs, most of which use contacts and a battery. The accompanying sketch, however, shows a scheme that uses neither of these features.

It is simply a reactance coil having a movable core, actuated by the float, the water level being gaged by the brightness of the lamp. I used an indicator of this kind to indicate the approximate height of the water in the forebay of a hydro-electric plant. Two 8-cp. lamps connected in parallel and placed side by side in a conspicuous position in the dynamo room were connected through 1800 ft. of No. 10 single copper wire to the reactance coil placed at the forebay up on the mountain side. The steel water pipe was used for the return circuit. The lamps burn brightly at low water and dim at high water and after a little experience the operator is able to judge very closely the intermediate points.

For those who might want to make such an indicator where the conditions are similar to the foregoing, I submit the following data:

The difference in water level to be indicated was 20 in. The coil was 20 in. long, made by winding 13 layers of No. 18 cotton-covered copper wire on a piece of fiber tube of 7/8 in. inside diameter; core of 5/8-in. solid soft



REACTANCE COIL IN CIRCUIT OF SIGNAL LIGHT

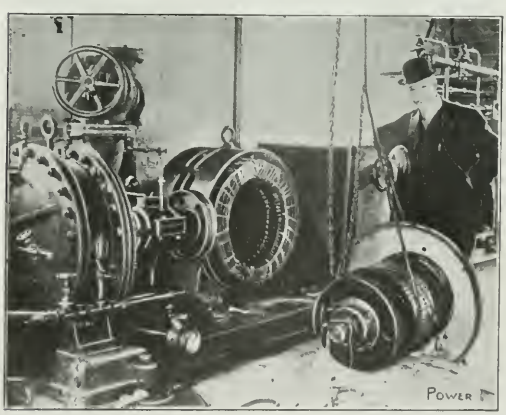
iron, 20 in. long or over. One 16 cp. or two 8 cp. lamps were connected in parallel and put in series with the coil. The supply was 110-volt alternating current.

F. J. STOREY.

Richmond, Calif.

Accident to Induction Motor

A 125-hp. two-stage motor-driven turbine pump was installed for fire purposes. It had been run only a couple of times for a few minutes on each occasion and, at the third trial, the operator heard a tearing noise and immediately shut off the power. Upon removing the end of the motor casing, it was found that some of the coils had dropped and came in contact with the fan blades, which had torn the insulation from several of them.



ARMATURE REMOVED AND FIELD COILS TIED IN PLACE

The armature was removed, the torn insulation retaped and the coils carefully tied up. The illustration shows the armature removed and the method used to tie up and support the coils.

JAMES E. NOBLE.

London Junction, Ont., Can.

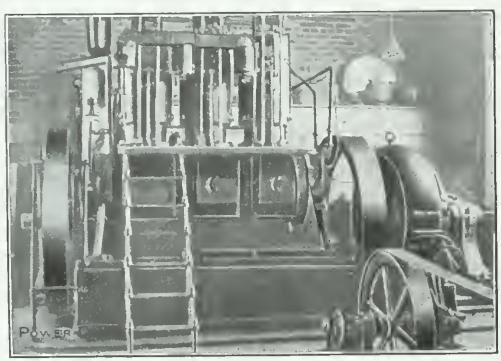
GAS POWER DEPARTMENT

Operating Costs of Small Gas Engine Plant

By M. W. Utz

The following operating data are taken from the records of the Municipal Electric Light Plant of Minster, Ohio. The plant consists of one 12x12-in. and one 11x12-in., three-cylinder vertical four-stroke-cycle gas engines direct connected respectively to 62.5- and 50-kw., 250-volt direct-current generators. Engine No. 1 is herewith shown.

Both engines have make-and-break ignition, current for engine No. 1 being supplied by a magneto bolted to the engine frame and driven by a friction pulley from the flywheel; engine No. 2 is supplied by a ¼-kw. generator belted to the engine shaft. Both are equipped with batteries for starting or for use in case of a breakdown of the magneto or generator.



One of the Main Units

Compressed air at 225 lb. pressure is used for starting, this being furnished by a 3x4-in. duplex compressor, belt-driven by a 2-hp. gas engine. Natural gas of about 900 B.t.u. per cu.ft. is used for fuel. The engines are lubricated by the splash system and use four gallons of oil per 24 hr., the oil costing 19c. per gal.

The first cost of the engines, generators, air compressor, tanks, switchboard, etc., was $9000. Engine No. 1 has been in service three years, running about 16 hr. per day, and engine No. 2 has been in service two years, running about 18 hr. per day. The repairs on these engines since their installation have been practically nothing and the service is good.

Owing to the fluctuations of the day load, and the ease of starting an engine, one engine is started and stopped quite frequently. An engine can be started, brought up to speed and cut in at the switchboard in parallel with the other in little over a minute.

Table No. 1 shows how the load varies during different periods for a typical daily run, and Table 2 gives the gas consumption and electrical output for the month of April, 1912. Table 3 gives figures on the cost of power for one month, is fairly accurate and also a good average for the year.

TABLE 1. TYPICAL DAILY LOAD

Time	Cu.ft. of Gas Consumed per Hr.	Output in Kilowatt-hr.
12 M.	415	26
1 a.m.	410	24
2	390	24
3	385	23
4	375	20
5	325	13
6	400	25
7	550	40
8	475	36
9	475	35
10	475	35
11	400	26
12 noon	375	25
1 p.m.	575	45
2	475	36
3	500	40
4	475	38
5	425	26
6	475	31
7	585	43
8	590	43
9	450	27
10	400	23
11	325	19
12		
Total	10,725	723

Average gas consumed per kilowatt-hour = 14.8 cu.ft.
Oil consumed = 4 gal.

TABLE 2. GAS CONSUMPTION AND ELECTRICAL OUTPUT FOR ONE MONTH

Date	Cu.ft. of Gas Consumed	Output in Kilowatt-hours	Fuel cost per Kilowatt-hour, cents
April:			
1	9,500	560	0.0050
2	9,850	599	0.0049
3	10,200	635	0.0048
4	9,825	587	0.0050
5	9,725	566	0.0051
6	10,950	684	0.0048
7	6,350	369	0.0051
8	10,000	642	0.0046
9	9,850	625	0.0047
10	10,050	638	0.0047
11	9,875	653	0.0045
12	10,000	660	0.0045
13	10,650	682	0.0046
14	5,875	304	0.0058
15	10,125	665	0.0045
16	9,750	621	0.0047
17	10,950	724	0.0045
18	10,725	723	0.0044
19	10,325	677	0.0045
20	10,400	658	0.0047
21	5,550	287	0.0058
22	9,525	561	0.0050
23	9,375	578	0.0048
24	9,175	552	0.0049
25	8,975	536	0.0050
26	9,375	575	0.0048
27	9,775	615	0.0047
28	5,375	276	0.0058
29	10,900	705	0.0046
30	10,250	651	0.0047
Total	283,250	17,608	Average 0.0482

TABLE 3. TOTAL COSTS FOR MONTH

Fuel:	
283,250 cu.ft. of gas at 0.30 c. per 1000 cu.ft.	$84 97
Labor:	
2 engineers at $55 each	110 00
Oil:	
120 gal. at 0.19c. per gal.	22 80
Interest, depreciation, etc. 15 per cent per annum on $9000	112 50
	$330 27

$$\text{Cost per kw.-hr.} = \frac{330.27}{17,608} = 1.87\text{c.}$$

The Paragon Engine

One of the difficulties met with in gas- and oil-engine practice is the high pressure and temperature of the exhaust gases, which not only carry off considerable heat, but also have to be passed through a silencer. Many attempts have been made to overcome this drawback by adopting the compounding principle as in steam engines and by other means, but hitherto none of these has attained any appreciable measure of success. W. P. Durtnall, however, the inventor of the "Paragon" system of electrical transmission of power for the propulsion of vehicles, ships and railway trains, has recently devised an entirely new method of solving the problem, which seems calculated to achieve the desired end without introducing complications into the design.

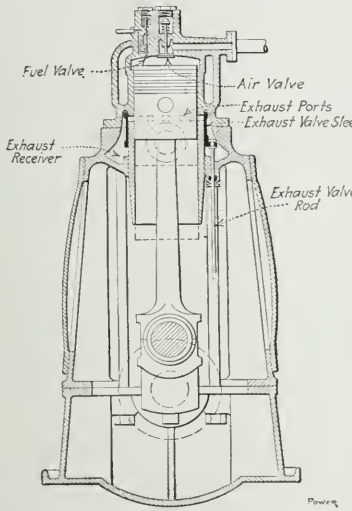


FIG. 1. SECTION THROUGH ENGINE

To put the matter briefly, Mr. Durtnall controls the exhaust valve in such a way that the travel of the piston during expansion of the charge is twice as long as its travel during compression. It is put into practice without in any way affecting the regularity of the stroke of the piston, which is always of the same length. The principle is applicable to both two-stroke-cycle and four-stroke-cycle Diesel, as well as gas engines.

Fig. 1 shows a section of a Diesel engine of the two-stroke-cycle type using the "Paragon" cycle. Besides the fuel valve there is a valve to admit air for scavenging, both in the cylinder cover, and the exhaust valve is a sleeve covering a ring of ports around the middle of the cylinder, and operated by a rod from the crankshaft. The cycle is as follows:

Starting with the piston at the top of the compression stroke, and the crank on the inner dead center, as shown, the air in the compression space is at a pressure of about 500 lb. per sq.in., and a temperature of about 1000 deg. F. As the crank passes the center, the fuel oil is sprayed into the compression space, and immediately ignites, continuing to burn and to maintain the pressure over a portion of the working stroke, as in the ordinary Diesel type. After the fuel is cut off, the gases expand until the piston reaches the end of its stroke, the exhaust ports being closed by the sleeve; at the end of the stroke the gases are almost at atmospheric pressure and a comparatively low temperature, and the exhaust valve now being opened, they escape almost noiselessly. The air scavenging valve is now opened, and a rush of air through the cylinder and out of the exhaust ports sweeps away the products of combustion, until the piston on the return stroke covers the exhaust ports and begins to compress the charge of pure air trapped in the cylinder. The rise of pressure closes the air admission valve, and at the end of the inward stroke the cycle is repeated.

It will be seen that the expansion stroke is twice as long as the compression part of the stroke. The indicator diagram obtained is shown in Fig. 2, the stroke being represented by the length *EC*. In an ordinary Diesel engine with this length of stroke, the compression space would correspond to *EH*, but in the Paragon engine the compression space is reduced to *EG*, and compression does not begin until the piston arrives at the point *D*. At *A* compression is complete, from *A* to *B* the fuel is burning, and from *B* to *C* expansion takes place, release occurring at *C*. The shaded area *F* represents the work of compression, the remainder of the diagram being a measure of the useful work done on the piston.

Fig. 3 shows the diagram of a Paragon engine working on the four-stroke cycle. In this case compressed air is not used for scavenging. On the suction stroke, from *A* to *B*, air is drawn into the cylinder; at *B* the induction valve is closed, and the pressure in the cylinder falls below atmospheric pressure, as shown by the line falling from *B* to *D*, the effect of the difference of pressures on the front and back of the piston being to check the motion of the piston and the parts attached to it, and on the return stroke to accelerate these parts, thus cushioning the stroke as in a steam engine, without appreciable loss of energy. At *B* on the return stroke compression commences, and at *E* it is complete; the fuel is then sprayed in, and burns during the working stroke up to the

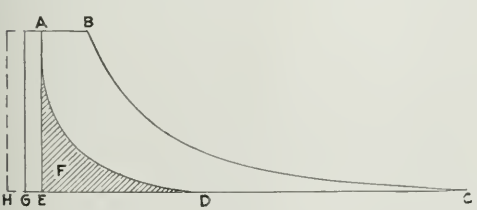


FIG. 2

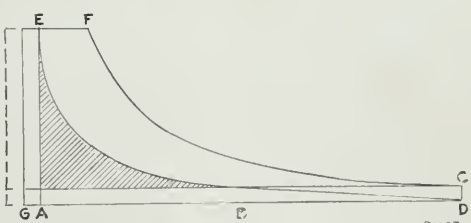


FIG. 3

point *F*, after which expansion proceeds to the end of the stroke at *C*. The exhaust valve is opened as the crank passes the center, and on the return stroke the piston sweeps out the burnt gases, the cycle being then repeated. Evidently the same effect is obtained as in the case of the two-stroke-cycle engine.

Owing to the reduced wall surface of the compression space, it is claimed that less heat is lost to the jacket, and the longer expansion permits a larger proportion of the energy to be abstracted from the gases, so that an increased thermal efficiency is obtained. The engine can also be worked on the Beau de Rochas cycle, in which the compression pressure is only about 80 lb., the engine being run with gas.

Pound in Engine Cylinder

Replying to Mr. Abel's inquiry, appearing in the Jan. 28 issue, it seems very probable that the pound is caused by too early ignition in one of the three cylinders. This condition could occur from anyone or a combination of causes, such as the crankpins not being spaced exactly 120 deg., the timing possibly not occurring at exactly 240 deg., or a combination of the two inaccuracies, both being added in the one cylinder.

The following is a much more probable solution:

A crankshaft so weak as not to be able to withstand the torsional strain at full power without presenting one crankpin out of its proper timing, might cause such a condition as described. The energy stored in the flywheel on the end of the crankshaft not coupled to the generator, might cause a lag in the crankpin motion at full load that would not show when the power is reduced by means of an over-rich mixture, or when the power demands are lessened by a partly closed throttle and later timed ignition.

A. E. Potter.

New York City.

Care of Dry Cells

The dry cell has many points in its favor as a source of ignition current for small gas and gasoline engines, especially those used for portable work, such as operating concrete mixers, sawing rigs for contractors' use and other similar work. A set of dry cells has the advantage over any other source of ignition current that the first cost is low, and as magnetos, and, in fact, all devices for supplying ignition current, are liable to injury or damage through exposure in the kind of work referred to, the loss is small, even if the battery is ruined through accident.

The dry cell, unless carefully protected, is liable to injury by rough handling and the jolting incident to the service for which it is used. The connections are likely to become loose, the hard wax seal broken or the cells short-circuited through carelessness in allowing tools to be thrown across them. The life of the dry cell is often materially shortened through drying out. It is also liable to be short-circuited through exposure to rain and snow.

With the idea of overcoming these difficulties a set of dry cells was placed in a box just large enough to accommodate them and deep enough so that the tops of the binding posts were about an inch below the top of the box, the connections made and the terminal wires led outside the box. The entire space around the batteries was then filled with melted paraffin up to a level with the top of the box. Paraffin shrinks in cooling, but with the space allowed between the tops of the binding posts and the top of the box all the cells and connections were completely covered with the wax when cold. The battery was then put in service on a portable outfit, where it was exposed to every change of temperature and humidity. During its life it passed through one severe rainstorm, being left outdoors unintentionally, a circumstance that would have ruined an unprotected set of batteries. The engine was used intermittently and for this class of service the battery lasted ten months, a very remarkable record.

The cost of fixing the batteries in this manner is very small. If a box just large enough is used, the cost of paraffin is small. In the foregoing, 4 lb. were used, costing 6c. per lb. In addition to the economy, the assurance that the batteries are always in good condition and ready for service is worth considerable.

James H. Beattie.

Washington, D. C.

Misleading Indicator Diagram

While running an economy test on a 5¾x12½ in. Otto gas engine using illuminating gas as fuel, an indicator diagram was obtained as shown. At first sight it seems an exceptionally good diagram with nothing irregular. If the cycle be gone over, however, it will be found that the suction line apparently lies above the atmospheric line. This represents an impossible condition, since the inlet gases were at atmospheric pressure, and they will flow only when the final pressure is lower than the initial.

Several diagrams similar to the one shown were obtained, indicating that the irregularity was not due to the shifting of the card on the drum. The trouble was then

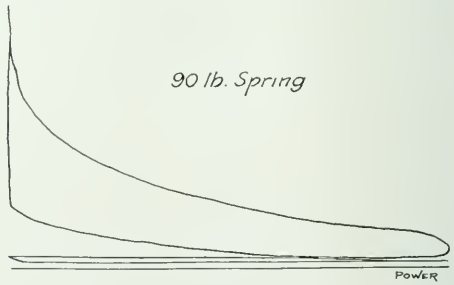


Diagram Showing Suction Line above Atmospheric Line

investigated, and was found to be in the indicator mechanism. There was lost motion due to a loose connection between the vertical link running up from the piston and the beam to which the pencil is attached. This allowed the pencil to remain above the atmospheric line whenever it was applied to the drum, the friction between the pencil and the paper preventing the beam from falling so as to trace the suction line.

L. Grossbaum.

New York City.

HEATING AND VENTILATION

Condensing Plants for Large Commercial Buildings

In an article in the Jan. 21 issue, Mr. Evans has advanced the proposition of applying the present-day practice of central stations to office-building isolated plants when the load exceeds 200 hp. This idea is in many respects excellent and is worthy of serious discussion. The problem, however, is hardly capable of any general solution and no general statements can be drawn up that will apply equally to all cases. In the final analysis each building must be taken as a separate problem and the most economical system can only be determined after a careful study of all the factors.

There is hardly a building in New York City that could compete with the Edison Co. were it not for the fact that during the six or seven months of the year when the lighting load is the heaviest, heat is necessary, and the amount of coal required is practically the same whether the electricity is generated or purchased. It is then only during the summer months that the cost of generating electricity is an important item and the saving during these months when the load is the lightest would not be in most cases suitable to warrant the expense of more economical engines and condenser equipment.

In presenting his side of the case, it would seem that Mr. Evans has avoided some of the disadvantages and also used figures that hardly agree with current practice. In a building over 10 stories high where forced hot water is used for heating and it is necessary to divide the system into independent units, there is the disadvantage of having the equipment in two parts of the building and a necessary loss of time in going from one to the other. Also the problem of making the steam line to the exhaust heater tight under 20 in. of vacuum becomes difficult. In a 20-story building with a heater on the tenth floor the steam connection would be some 150 ft. long with several fittings and couplings.

The statement that all large buildings have more or less undesirable space in the basement is hardly true. From the tight squeezes in many office-building power plants it would seem that just the reverse is the case. In figuring the cost per year for mechanical service with and without isolated plants, the extra space required by the engines, generators and switchboard is usually charged against the plant. In this case the value of the floor space required by a cooling tower should be charged against the saving effected by its use.

The figure of 21 lb. of steam per kilowatt-hour at the switchboard for a condensing engine is hardly a fair one as a compound Corliss engine working under ideal conditions would be necessary to obtain this water rate. This type of engine is rarely used in office-building work.

The difference in the water rate of steam engines running condensing and noncondensing is about 20 per cent., and the amount of steam required for the condensing apparatus will average 7 per cent. of the steam used by the engine so that a condensing plant is much nearer to 13 than 25 per cent. more efficient than a noncondensing plant. With hot-water heating the point that just enough heat can be furnished to provide for the outside temperature and that overheating of the rooms and the wasting of heat to the atmosphere through open windows is eliminated, is well taken. It is a well known fact that in large office buildings heated by steam the radiators are very rarely touched, the temperature of the room being regulated by opening one or more of the windows.

In most buildings in New York City it is the author's opinion that the results would not favor a system such as suggested by Mr. Evans, yet the idea is of enough value to be considered as a probable method. In some localities, such as San Francisco, where the heating load is much less than the light and power loads, it would probably be the most economical system and might be the deciding factor in favor of a plant when other systems would not justify it.

W. L. Durand.

Brooklyn, N. Y.

In the following, an attempt will be made to answer in order the points in Mr. Durand's discussion as to the feasibility, from a commercial standpoint, of the arrangement of the plant proposed in the Jan. 21 issue.

It is conceded that each particular plant would have to be analyzed before a decision could be made on the type of equipment to be installed, precisely as at present. The discussion mentions the comparatively slight variation in heat consumption of steam systems, for varying outside weather conditions, and the wastefulness due to open windows when rooms become overheated. The familiarity of engineers with the physical action of steam-heating plants causes a lack of appreciation of the advantages of the wide range of temperature and heat requirements of a hot-water system under forced circulation, and the bearing of this feature on the method of operation proposed. There are very few commercial buildings of any size where the power load, a large portion of the time, does not provide steam greatly in excess of the heating requirements. A glance at the exhaust heads in lower New York any winter afternoon will show the fallacy of Mr. Durand's statement that the amount of coal required would be nearly the same whether the electricity were generated, and exhaust used for heating, or purchased and the heating operated by live steam.

Under the conditions named, a portion of the power load may be operated to furnish steam under reduced vacuum for heating, and the balance may be operated under the maximum vacuum on a separate machine. The condenser would have to take care only of the surplus power load plus about 5 per cent. of that required for heating. The full condensing effect of the heating system is obtained at practically no expense.

Where automatic heat control is provided, a steam system utilizes nearly the same quantity of heat as a

water system; but the pressure and temperature of the exhaust steam, which affects the engine economy, is the same at all times or a little worse in mild weather. Where the power load is not much over 200 hp., it would probably not pay to install a cooling tower of large size. Vacuum could be carried in connection with the hot-water system in winter, according to outside weather conditions and the exhaust steam wasted to atmosphere in summer, as it is at present. In this case, the cooling tower or condenser would be very small and all of the condensing effect produced by the heating system. A fan system for ventilation, operated in connection with the water system, would answer the same purpose.

The fact that the water system uses just the amount of steam required at comparatively low temperature in average weather, makes condensing profitable. It would be practically impossible with a vacuum steam system.

TABLE 1. STEAM RATES OF 500-KW. TURBINE AT DIFFERENT VACUUMS AND HEATING REQUIREMENTS

Outside Temp., Deg. F.	Per cent. of Total Day Heating, Taken by Each Period (1545 hr.)	Av. Temp. Heating Water, Deg. F.	Vacuum to Produce Water Temp., In.	Steam Rate per Kw.-hr. (500 kw. Unit)	Steam Rate in Per Cent. of Atmospheric Rate	Steam for Heating in Per Cent. of 0 to 10-Deg. Period
0-10	0 6	200	0	43	100	100
10-20	3 25	190	6 4	39	90	90
20-30	13 25	177	11 5	35	80	79
30-40	32 4	163	17	31 4	73	70
40-50	22 6	143	22	27.3	63.5	56.4
50-60	27 8	115	26	23	53 5	46.2

Table I gives the exact operating conditions of a turbine plant and hot-water heating system, with average temperature of the water, amount of vacuum to produce the water temperature and steam consumption of the turbines without auxiliaries. The amount of steam required in the 0- to 10-deg. period is taken as 100 per cent. The percentages of time are those during the day taken from the Weather Bureau reports. It may be noticed that the range in percentages of the turbine for a constant load vary almost exactly with the heating requirements. This is not true with the reciprocating engine. The figures show that a constant load could be carried throughout the winter on a turbine; and, by varying the vacuum, the exact amount of steam in temperature and quantity will be provided for the heating system for all outside weather conditions. The rates given are for a 500-kw. Westinghouse-Parsons turbine. The table shows that 17 in. of vacuum, and above, can be carried over 80 per cent. of the heating season, for the power steam used on the heating system, with practically the same amount of radiation and the same temperature conditions in zero weather as would be required by a vacuum steam system. As the heating system would be operated in any case, this condensing effect could be obtained for practically nothing. Mr. Durand's statement that vacuum could be carried only in the summer, is erroneous to this extent. The table shows that for only about 15 per cent. of the time would the economy of the condensing machine be seriously interfered with.

In a vacuum steam system, the various vacuum pumps would require from 100 to 150 lb. of steam per horsepower-hour; while the water system would require more power at a much lower steam rate.

In comparing the reciprocating engine with the turbine, the friction load of the former is seldom taken into account as the engine is rated on indicated horsepower and the turbine on brake horsepower. The friction load of a turbine is small compared with that of a compound engine, as the turbine, due to the high speed, must be thoroughly balanced.

Table 2 compares a 500-kw. compound-condensing engine and a 500-kw. turbine under different loads at atmospheric pressure and 26 in. of vacuum, with saturated steam at 150 lb. gage pressure. The friction load of the engine is assumed for all loads at 12½ per cent. of full load rating or practically 80 hp. At full load and one-quarter overload, the turbine has a somewhat greater steam consumption than the reciprocating engine at 26 in. of vacuum, but at one-half load its steam rate is less. The comparatively small size of the turbine and generators, due to the higher speed, reduces the initial cost over an engine unit, and the space occupied will be about one-quarter, an important item in Mr. Durand's discussion. The oil question and separating apparatus would be eliminated on the turbine equipment and the foundation is another item in favor of the turbine.

In most reciprocating plants, several sizes of unit are provided on account of the poor economy of the reciprocating engine under one-half load. This is aggravated by clearance and cylinder condensation, which do not appear in the indicator diagrams. The turbine rate varies only ½ lb. between 50 per cent. load and 25 per cent. overload operated under vacuum, while the reciprocating engine shows an increase of 40 per cent. at one-half load. This means that with the turbine the number of units can be reduced without materially affecting the economy of installation.

When the turbine is operated on the heating system under partial vacuum, no adjustments are necessary; while with the compound engine the cutoff must be varied with the vacuum, and possibly the load, and the receiver pressure changed. The author has personal knowledge of a turbine plant operated with two machines for the last five or six years, under a 24-hr. load, ranging from 250 to 650 kw., with two peaks. Space had been provided for two additional units, but these have never been installed.

There is no question about the poor economy of a turbine when operated without vacuum, but where the vacuum is reduced in zero weather to provide steam for heating there is little difference in its economy and that of the reciprocating engine, as live steam would have to be added in the case of the latter.

Mr. Durand's assumption that the cooling tower could only be used during the summer months is caused by the known excessive heat requirements of steam-heating systems in moderate weather. In zero weather there would be practically no difference in economy between the non-condensing steam-heating system and the hot-water system; but, according to weather reports for New York and vicinity, the temperature is below 20 deg. only about 15 per cent. of the time and, during the present winter, there have been very few hours below 32 deg. during the daytime.

San Francisco is mentioned as a favorable place for the type of system proposed, on account of the mild climate. As the amount of vacuum is determined by the temperature of the circulated water and the amount of radiation, regardless of the latitude, it would probably be better economy to use less radiation and operate on only a slightly lower temperature of water than in New York, thus keeping the cost of the heating system low.

As far as the night load is concerned, the power seldom, if ever, furnishes sufficient steam for heating and a discussion of this period will be eliminated.

Regarding the placing of the hot-water pumps on an upper story, as the circulating pumps would be motor-driven, they would require less attention than the motors for overhead traction elevators. Attention is admitted and required; but, in connection with fan motors and traction elevator equipment in various parts of a high building, it would not be a serious matter. The valves for regulating the steam to the system on the upper level would all be in the basement or engine room, together with all thermometers and gages. This arrangement does not contemplate the regulation of the heat by varying the speed of the pump. The difficulty of making the exhaust pipes tight is admitted; but there would be only about four fittings and straight lengths of pipe and, perhaps, two valves. With the condensing equipment to assist, and an average vacuum of about 20 in., it is not insurmountable. When carrying full vacuum in summer or winter, this line would be cut out entirely.

The use of turbines over compound Corliss engines would give more than space sufficient for a cooling tower in a less desirable location from a rental standpoint. For a 1000-kw. unit, using 20,000 lb. of steam per hr., two spaces 12 ft. in diameter and head room of 18 ft. would be sufficient for the cooling towers.

The 21-lb. rate per kw.-hr. referred to was for a turbine without auxiliaries and was operated on a heating system, the condenser only keeping the circulating water from becoming overheated and regulating the temperature and vacuum.

It has been the writer's observation that few plants dare to load the units up to full load on account of someone outside suddenly throwing on sufficient additional load to overload the generators. This varies in different places. In office buildings, the engineer has greater control of the load, but in large loft buildings, furnishing power to tenants, the load is out of the engineer's control to a great extent. Under these conditions, the turbine would show some advantages.

Regarding the criticism of the high percentage of difference in operating cost between condensing and noncondensing conditions, the quantity was intended to apply to a comparison of the use of simple, high- or medium-speed engines, as generally operated against slight back pressure in installations of this class, with the possibility of condensing operation in connection with the hot-water heating system. Mr. Durand admits that compound engines are infrequently installed in this class of work and the comparison given shows that the author was not far off in his general assumption.

The following data regarding a plant about to be installed in a 32-story office building, now in course of erection in New York City, is submitted. Four 400-kw. compound Corliss units and one 200-kw. unit have actually been purchased. There will be 100,000 sq.ft. of heating surface, 32 elevators will be installed and these, with what miscellaneous power will be required in such a building, will aggregate about 500 kw., a load which would just balance the heating with steam or water in zero weather.

With a turbine, the heating system would produce 20 in. of vacuum on the average load of 500 kw. 80 per cent. of the heating season, the cooling tower taking about 10 per cent., or 50 kw. The cooling tower would have been designed to take care of 1000 kw., which would be ample to produce 26 to 28 in. of vacuum for the average summer load. The lighting load will be at least 400 kw. for 1000 hr. in winter, and this could have been operated entirely on full vacuum, so the cooling tower would have considerable more than the summer load to help pay for interest and depreciation. The reduction in boiler power, when running condensing, and the lower cost of turbine units over reciprocating engines, would have been nearly sufficient to pay for the cooling tower and condensing equipment.

The entire cost of power and heating equipment on the hot-water condensing basis would have been some $50,000 less than for the vacuum steam system with automatic heat control and the Corliss engine outfit, and at least 20 per cent. saving in fuel and water could have been effected.

In estimating the steam consumption of the engine, the author perhaps erred on the low side: but if he had placed it at what he actually thought it to be in practice, some other person might have claimed that it was too high.

The writer submits the following figures, which he considers fair, as the average difference between condensing at 26-in. vacuum and running noncondensing with a compound engine operating on saturated steam at 150 lb. gage. The difference between this outfit and a simple engine would, of course, be greater. In Table 2 a rate of 16 lb. per b.hp.-hr. is given for a 26-in. vac-

TABLE 2. STEAM RATES FOR 650-HP. COMPOUND ENGINE AND TURBINE

Per cent. load	Hp.	Rate per I. Hp.	Total lb. Steam	Net Hp.	Rate per Net Hp.	Turbine B.hp. Rate
		26 in. vacuum, sat. steam, 150 lb. gage				
125	812	14.5	11,774	732	16.1	18.5
100	650	14	9,100	570	16	18.5
75	488	15	7,320	408	18	18 0
50	325	17	5,525	245	22.5	18 5
		Atmospheric exhaust, 150 lb. gage				
125	812	20.3	16,484	732	22.52	29 4
100	650	18 5	12,025	570	21.1	28
75	488	20 0	9,760	408	24 0	30
50	325	24.5	7,962	245	32.5	34

Engine friction on all loads = 80 hp.

uum, and 21.1 lb. when operating against atmospheric pressure. This shows

$$\frac{5.1}{16} = 0.319 = 32 \textit{ per cent. increase}$$

$$\frac{5.1}{21} = 0.241 = 24 \textit{ per cent. decrease}$$

gross in steam consumption between condensing and noncondensing.

When comparing condensing and noncondensing operation, a correction is necessary for the difference in the temperature of the feed water. When running noncondensing, the feed water is at a temperature of 200 or 210 deg. and about 100 deg. for 26 in. of vacuum. The auxiliary steam necessary to raise the water 100 deg. would be

$$16 \times 100 = 1600$$

$$\frac{1600}{1000} = 1.6 \textit{ lb.}$$

steam per hp.-hr., making the actual rate condensing 17.6 lb. instead of 16 per hp.-hr. The injection water will have to be pumped against 75-ft. head, including the height of the tower and friction of the piping. If the building is not too high, the tower may be placed on the roof without fans. The static head on the pumps

and apparatus will determine this factor; otherwise, it will have to go in the basement or sub-basement. In the case referred to, a flue 10 ft. square and 450 ft. high could have been arranged, which would have furnished 100,000 cu.ft. of air per min. under about 2 in. of water pressure.

Assume that the cooling tower will cool the water 25 deg. and that the surface condenser is large enough so that with a 20-deg. rise all steam will be condensed. The latent heat at 26 in. of vacuum is 1026. Then,

$$16 \times 1026 = 16{,}416 \textit{ B.t.u. per b.hp.}$$

$$\frac{16{,}416}{20 \times 60} = 13.68 \textit{ lb. water per min.}$$

Circulating this against 75-ft. head would require

$$13.68 \times 75 = 1026 \textit{ ft.-lb. per min.}$$

If the hotwell and air pumps each handle 16 lb. of water per horsepower of the main unit per hour against a head of 75 ft., it will require

$$16 \times 75 \times 2 = 2400 \textit{ ft.-lb. per hr., or } 40 \textit{ per min.}$$

$$1026 + 40 = 1066 \textit{ ft.-lb.}$$

$$\frac{1066}{33{,}000} = 0.0323 \textit{ hp.}$$

With 50 per cent. efficiency, 0.0646 hp. would be required. Adding 25 per cent. for electrically driven pumps, would give 0.08 hp., or $0.08 \times 16 = 1.28$ lb. per b.hp.-hr. of the main unit. This is less than the 1.6 lb. required for feed purposes, so that steam-driven machines may be used without loss of economy up to the limit and the exhaust used for feed purposes. Correcting the steam rate, gives 17.6 lb. for 26 in. of vacuum and 21.1 lb. noncondensing. Then

$$\frac{3.5}{17.6} = 20 \textit{ per cent.}$$

net for the increase in steam consumption when changing from condensing to noncondensing, and

$$\frac{3.5}{21.1} = 16.6 \textit{ per cent.}$$

for the saving net of condensing over noncondensing conditions. Where a fan arrangement is required for the cooling tower, the figures would, undoubtedly, approximate those of Mr. Durand's, but in most cases, it is the belief of the author that fans can be avoided.

It should be remembered that this is true only for full-load conditions. If the water rate condensing for all loads were averaged, the percentage of difference would be as follows: From Table 2 the average condensing rate is

$$18.15 + 1.81 = 19.96 \textit{ lb.} = 20 \textit{ lb.}$$

The average noncondensing rate is 25 lb.

Then the percentage increase is $5 \div 20 = 25$ per cent., and the percentage decrease, $5 \div 25 = 20$ per cent.

The water saving through the use of a cooling tower would be about 3 lb. per hp.-hr. on all steam that ordinarily escapes to the atmosphere winter and summer, as plants are operated at present, at $1 per 1000 cu.ft.

It is admitted that the turbine is not as economical as the steam engine at full load, but with the less number of different-sized units, space occupied and the other items enumerated, it should have careful consideration. It is, of course, out of the question with vacuum steam systems.

The author would appreciate a further expression of opinion from Mr. Durand on the above discussion, or other readers of POWER interested along these lines, as improvement can only be made by intelligent suggestion and criticism.

IRA N. EVANS.

New York City.

Water Leaves Boiler

In answer to Luther Walling's inquiry in POWER of Jan. 21 regarding backing up of water in risers of the one-pipe steam-heating systems, would say that the risers in the wing are overloaded beyond their capacity. The size of returns given by Mr. Walling are too small. Good American practice is to provide returns having one-quarter of the area of the steam line. In this case for the 3½-in. steam line a 2-in. return should be provided, and for the 3-in. steam line a 1½-in. return. There is also a way to relieve overloaded risers. If each riser is connected to an overhead equalizing pipe, the greatest pressure in the nearest riser will expand toward the farthest riser and prevent excessive pressure drop. If Mr. Walling will use an overhead equalizing pipe and put in extra return lines to meet the difference in area he will have no further trouble.

New York City. C. W. ROOS.

I think the return ends of the circuits have been reduced too small. They should have been at least 2 in. in diameter to give good satisfaction on a single-pipe job. However, if a swing-check valve be placed between the return line and boiler, with a valve on each side to allow for inspection and repair of the valve, this will keep the water from backing out of the boilers. When a sufficient head of water from condensation is obtained, the circulation will be all right. I would also recommend the placing of a tee, with the side opening looking down, in the supply header. From the bottom of the tee drop a 1½-in. line into the return. This will keep the header dry and take care of any priming of the boiler. If the pipe work is properly arranged, the above repairs made, and a pressure of 3 to 5 lb. is carried in the boiler, there should be no more trouble.

Moorhead, Minn. J. H. NORTON.

The water leaves the boiler because the supply and return are connected too close together at the boiler. In other words, if the supply connection is near the front of the boiler, the return should enter the rear end. I would suggest running all returns into one large pipe and let it enter the center boiler opposite from the supply.

Bellefontaine, Ohio. W. T. HURD.

Mr. Walling should close the main steam valves on the boilers and build up the steam pressure to the blowing-off point. Then open the main steam valves on the boilers slowly and have the air cocks open on the return pipes in the basement so that the temperature of the return may be determined. When the water becomes hot, indicating that the supply and return pipes have become equalized, the air cocks may be closed and the return valves opened slowly. If they are opened before the steam and return pipes are equalized, water will rush out of the boilers.

Warm Springs, Mont. EDWARD N. JOHNSON.

EDITORIALS

Are Your Boilers Properly Inspected?

A steam-power plant represents a cash investment from which no direct profits are derived. From the day it is started it begins to deteriorate, parts begin to wear and the metal in the boiler is subjected to the action of furnace temperature, gases and to feed-water impurities.

When a boiler is given proper care and when operating conditions are of the best, it may be in good condition after twenty years or more of operation. On the other hand, if the boiler is abused, left to operate without proper care, it may become unsafe within a few months.

There are three kinds of men in charge of boilers: those who are careful and know their business; those who are careful, but not so well informed, and those who are both careless and ignorant regarding boiler operation.

A boiler in charge of a man of the first class would be in safe hands and would, undoubtedly, be found in good condition. With the second sort of attendant, it would be difficult to hazard a guess as to the condition of the boiler. If the engineer did not know where to look for defects, the boiler might be in a dangerous condition, no matter how careful he might be about maintaining the water level at the proper height and in keeping the boiler clean of scale.

When the man in charge of the boiler is both ignorant and careless, the chances are that the boiler is not cared for and defects are allowed to exist which, even if not of a dangerous character at the time, would soon become so.

In the large well kept plant, the chief engineer does not have the time nor is it his duty to inspect boilers. Therefore, this work is left to a subordinate who may or may not be competent to do the work.

But who is to determine whether the boilers in charge of the two least responsible classes of men are safe to operate or not? What protection have those employed about the plant, in the mill, factory or passers-by against a deadly explosion? How can these persons be safeguarded in states and cities where the boilers are not under the supervision of the state or city boiler inspectors?

Remarkable as it may seem, a steam boiler can be insured in any reliable boiler-insurance and inspection company for, approximately, twelve dollars a year. Such an insurance means that trained experts in their line visit the plant, making one internal inspection and at least one external inspection, two if it is possible to do so, each year. These inspectors work under the direction of mechanical engineers who are authorities on the proper construction and safe operation of steam boilers and their appurtenances.

What is the result? Any defect that can be detected is located. The inspector is competent to determine what repairs are necessary.

An engineer may detect a defect, but rather than shut down the plant will permit the defect to remain until some convenient time for making the repairs. The inspector has no scruples. If the boiler requires repair, it must be attended to at once or the risk is canceled. Consequently, the boiler is kept in a proper and safe condition.

One has but to read the reports of steam-boiler inspection companies to ascertain how many boilers are found operating in a defective condition, many of which are dangerous. How many dangerously defective boilers are being operated which are not under the scrutiny of either state, city or company inspectors is a matter of conjecture. When based on the number of defective boilers inspected, they must number among the thousands.

Life is uncertain at best and it is foolish to invite danger by neglecting to have boilers properly inspected, and even more so when the cost is but twelve dollars a year and a little inconvenience.

⁂

Perpetual Motion Fallacy

About every so often, here, there or somewhere, another springs up who is confident he has discovered the secret of perpetual motion. As a matter of fact, there is no secret about it; those who have studied science at all very soon discover there is no such thing in nature as getting "something for nothing." Energy does not spring from nowhere and the law of its conservation has not been violated since the world began. Energy can be variously transformed and converted, but none will ever be found anywhere that it was not some time or other put in. It may have been centuries ago, as the heat energy latent in coal, or it may have been but a moment before, as the lifting of a weight and putting it on a table, where, by virtue of its position and the work done upon it in lifting it against gravity, it possesses a certain amount of potential energy.

The effort to discover perpetual motion seems to be something that is bound to come into the life of most mechanically inclined persons sooner or later. It is very like the measles, most of us have to have it and it is better if we have it early in life. It takes harder if we don't get it until maturer years and recovery is slower. Many youngsters, handy with tools and having a natural bent for making things, have, consciously or unconsciously, worked on this problem of trying to get a machine that would give out energy continually once it is started, without ever having any more put in. This is amusing to them and their elders; does them no harm and keeps them out of mischief for a time at least.

On the contrary, it is one of the most pitiful spectacles of life to see a full-grown, able-bodied man obsessed with the idea that he has a perpetual-motion scheme that will really work. Seldom can those better informed convince him of the impossibility of the plan. Everyone who seeks to discourage him is considered either a jealous enemy or a misguided friend. When such a person really gets over his mistake, it is an occasion for rejoicing. Many wreck their lives or their minds before they get through.

Someone has written a book containing a classification and description of all the fundamental perpetual-motion schemes and it is a splendid antidote. We commend it to all who are laboring under such hallucinations. Most of them will find their own pet schemes already catalogued in this mechanical rogues' gallery. This work should be a warning signal on the shoals and keep some from embarking on the fruitless search for the impossible.

Small Factory Power Plants

Engineers of small factory plants are usually required to find and correct troubles in the factory equipment that, in larger establishments, are cared for by a master mechanic, superintendent or foreman steam-fitter.

The chief difficulty confronting the engineer in such plants is that of reducing wastes due to thermal losses and friction. In this direction, the engineer does not always receive the support of the management or the necessary appropriations to enable him to accomplish good results. As preposterous as it may seem, it is the experience of engineers that in factories where these and other kinds of losses are enormous compared to the size of the plant, it is hardest to get the means whereby to check, even appreciably, the wastes.

Hydraulic presses containing steam plates, steam-heated rolls for drying or mixing, vulcanizers, steam tables, drying rooms, etc., are part of the equipment common in many such factories. These apparatus need skillful attention to prevent them from becoming a source of serious waste. Naturally, an engineer wants to provide such equipment with good thermometers, correct gages, steam traps and, above all, the wherewithall to return to the boilers the condensate, which is a large part of the total water evaporated in the boilers.

There are altogether too many plants of this kind where the engineer gets a half-hearted, unwilling co-operation from the management.

The engineer has been given a bitter lesson. He resolves never to go ahead, of his own volition, to improve his next plant unless the management gives him very good reasons to believe that his services will be justly appreciated. Like begets like, and appreciation of a man's good service is the best inducement for him to give all of the best that is in him.

Operating Costs

Attention is called to the figures given by M. W. Utz, on page 224, upon the cost of producing power in a small municipal plant.

Such data are of particular value for two reasons: First, they afford engineers operating similar plants a means for comparison with the performance of their own plants; second, they show that the small gas engine, when installed and operated under the proper conditions, can compete very successfully with large steam plants as regards total cost.

In this particular case, the cost is less than two cents per kilowatt-hour, fixed charges included. Of course, the labor and oil items are low, but these are offset by a rather low load factor.

It would be desirable if more engineers of small plants would submit their cost figures as Mr. Utz has done. While space would not permit publishing many; still, if enough contributions of this character were received, the data could be compiled and, if published in tabular form, would be invaluable to engineers of such plants.

Simple Metric Conversions

Our allegiance to the English system of weights and measures, like our religion and politics, is largely a matter of our bringing up. With all their faults we cling to the old "inch" and "pound" and most of us hope it will be left to a later generation to put them in the discard. This is through no special affection for them on our part for it is generally granted that the metric units are superior; the principal obstruction to their substitution is our dread of the upset and confusion during the transition.

Meanwhile some of us occasionally have to deal with both systems and drag out our handbooks with their conversion tables to search out the relationship.

Albert A. Cary has done a real service to engineers in developing the simple methods for approximate conversions presented on page 217. They make possible mental calculations of the English equivalents of the foreign units sufficiently close so that one can get a quick appreciation of their values by comparison with familiar standards. This article deserves to be preserved or the essentials of its rules memorized. The latter would go a long way toward removing our dread of the metric system invasion.

Self Instruction in Engineering Mathematics

Every ambitious engineer who, because of the ironies of life, was unable to obtain a knowledge of mathematics in his early years, knows that the lack of a thorough understanding of the essentials of this subject is the chief reason that he never advanced to a position of greater responsibility and one for which the remuneration is greater than that of the ordinary engineer's job.

It is all very well for arm-chair theorists who were fortunate enough to be born of parents who could afford to pay for their educational training, to say that "any man who will set himself to the task can accomplish it." This assertion applies well enough to the young man of today but it never applied to men who are getting past middle age and who, despite an honest effort in their early years, failed to acquire a self-education in mathematics. There was nothing available at the time to enable them to get a working knowledge of this subject.

It is only of late that books have been available from which a man of ordinary intelligence could learn the essentials of the higher mathematics, particularly as it relates to engineering. The average mathematician does not seem to know how to write such a book; in fact, some books written for self-instruction give one the impression that the authors were afraid the readers would really learn something from them.

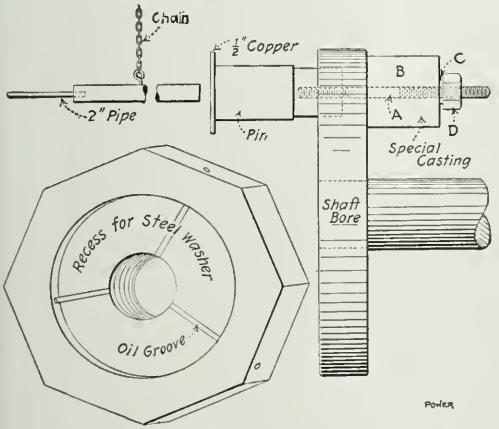
Happily, the young man who feels the need of a knowledge of mathematics can now get instructions from books that really instruct. The manner in which such books and our Study Course are received is evidence that they both fill a long-felt need.

READERS WITH SOMETHING TO SAY

Putting Crankpin in 5000-Horsepower Engine

A crankpin on the low-pressure side of a 5000-hp. cross-compound engine became so loose it had to be taken out and another pin put in. The dimensions of the new pin, which was made in the shop of the engine company, are as follows: Diameter, 14½ in.; length of bearing surface, 14 in.; thickness of crank disk, 11 in.; bore in disk, 12⅞ in., with a taper of 0.052 in. in 11 in. The weight of the pin was 1060 lb. and was left about $\frac{1}{32}$ in. large at the disk end.

The crank disk was a steel forging and it was planned to shrink the pin into the disk. The allowance for shrinkage was 0.007 in. Gasoline torches were used to heat the



SHOWING MANNER OF PUTTING CRANKPIN IN 5000-HP. ENGINE

disk, but after trying for twelve hours with no apparent success, this means of getting the pin in was given up.

It was then decided to pull the pin in by some device, which could be quickly made at the time. After the hole in the disk had been trued and the pin turned to the proper size, a device consisting of a 3½-in. diameter bolt *A*, a special casting *B*, a steel washer *C*, and a bronze nut *D*, were made.

A special wrench 6 ft. long was made to fit the nut *D*. The casting *B* was 24 in. in diameter by 24 in. long, and cored out in the center, the core being 4 in. in diameter so as to give plenty of clearance between it and the bolt *A*. The weight of this casting was 2380 lb. Both ends were faced off, one to rest on the disk over the pin, and the other for the bearing surface of the steel washer *C*, which fits into the face of the bronze nut. The nut was 12 in. in diameter, and the bearing side was faced and cupped as shown to receive a steel washer. Oil grooves were cut in the nut so that oil could be forced in between the washer and the nut to keep down the friction as the nut turned on this washer, which was 8 in. in diameter by $\frac{3}{16}$ in. thick.

From a piece of 6-in. steel shafting and a short length of 2-in. pipe, a battering ram 8 ft. long was also made. This ram swung from a chain the length of which allowed a swing of about 6 ft. To prevent injury to the pin when it was being rammed, a piece of ½-in. soft copper was used over the end of the pin.

When all the various parts were assembled and the ram hung in place, the large wrench was put on the nut *D*. A sling was then slipped around the wrench and over the hook of the chain tackle. By operating the wrench with the lifting tackle of the crane the crankpin was pulled into the disk for about 4 in. without the use of the battering ram. Then, while the lifting tackle was pulled so as to subject the wrench and pin to a tension, the battering ram was used to drive the pin in, two men operating the ram. After getting all the various parts assembled it required about two hours to pull the pin into its proper place. This engine has been running for a number of months under all conditions of load, and the pin seems to be as tight as it was the day we put it in.

It might be well to enumerate the symptoms of a loose crankpin.

Symptom 1. Pin heating up suddenly without apparent cause when there is a good bearing, the brasses properly keyed and the pin well lubricated.

Symptom 2. Occasional knocking or pounding, and heating of the pin, then tightening up and for a short while running smooth and cool. When a pin acts in this way one may rest assured that when the knocking and heating and the smooth running alternate, that the pin is loose and it should receive immediate attention.

Symptom 3. Trembling of a centrifugal oiler, when the brasses are properly keyed, or the turning of an oiler out of center.

Symptom 4. A breaking away of the beading on the back of the pin. Where pins are beaded over in this way and they become the least bit loose, the beaded end begins to disintegrate.

W. J. MAXWELL.

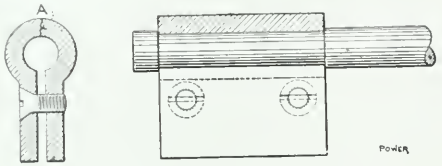
Indianapolis, Ind.

Broken Valve Rod Caused Pump Trouble

Some time ago I was troubled with a 6x4x10-in. single-acting boiler-feed pump stopping at one end or the other. I found that by changing the length of the valve rod it could be made to run again for some time, then it would stop on the other end. By changing the length of the valve rod the opposite way the pump would run again for some time then stop again as at first.

Changing the length of the valve rod to get the pump to run soon became monotonous and I took the pump

apart to see if I could locate the trouble. I found that the brass clamp on the end of the valve, as shown in the illustration, was broken at A, making it so loose that it would slip onto the larger part of the rod and stick there for some time, then do the same thing on the other side of the rod.



Broken Valve-rod Clamp

A new clamp was made and put on and the pump gave no more trouble from that cause. Little breaks often give more trouble than large ones because the little breaks are not so apt to be seen or discovered as soon as the large ones.

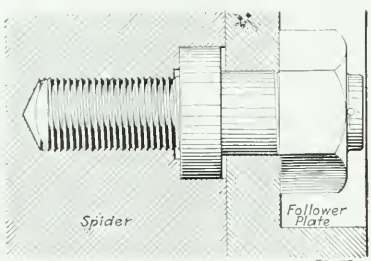
E. V. Chapman.

Decatur, Ill.

Stud for Pistons

One of the common mishaps that occur to engines is the breaking of the studs that fasten the follower plate to the spider of the piston.

It is fortunate, indeed, if the nut and broken stud pass out with the exhaust steam without doing any damage;



Safety Stud for Piston

but often a broken stud either smashes the piston, breaks the exhaust valve, twists the valve stem or breaks the cylinder head.

This happened in my plant so often that I decided to do a little investigating into the causes and remedies for such accidents. At the next break I secured a broken stud and by examining the steel with a microscope found it to be crystallized. To overcome this trouble I replaced all studs with ones made from Norway iron. I also changed the design of the stud so that, if the stud broke, it would not fall between the piston and the cylinder head. The stud was made with a collar, as shown in the sketch, and by reducing the diameter of the stud on the side next to the spider the stud would be more apt to break at this point.

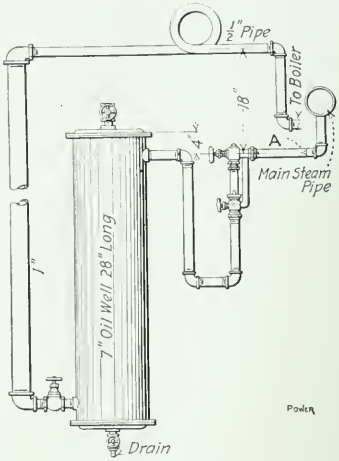
Since thus equipping all the engines I have had no more trouble.

A. Rauch.

Swissvale, Penn.

Lubricator Will Not Work

Having had considerable trouble getting lubricators to work properly on locomotive cranes, one was made and connected as shown, which does not work properly. The



Lubricator and Connections

lubricator feeds oil all right as far as the point *A*, and then backs in the sight glass. What is the trouble?

Robert Rush.

Stewartsville, N. J.

Ammonia for Hot Bearings

In Power I have often read articles pertaining to hot bearings and the different means the writers of these articles use to overcome them. I have never seen the following remedy given and it may prove of interest.

The refrigerating engineer need not have any fear as to the probability of a shutdown of the plant or engine, due to hot bearings, as the liquid ammonia he handles is one of the best things to cool hot bearings. Mix equal quantities of ammonia and water and pour it on the bearing or pin, as the case may be. It is surprising how quickly and easily this liquid will absorb the heat and leave the bearing perfectly cool; sometimes with frost on it, if enough liquid is used. Care must be taken not to get the liquid on the hands or face as it burns severely.

If the shaft or pin is very hot, do not pour the liquid in the bearing on the shaft or pin, but on the outside of the bearing, as the sudden chilling of the pin or shaft due to the liquid evaporating might crack or break one or the other. I have had eight hot bearings in my plant all at the same time, due to a breakdown of the oil pump supplying the lubricating system. All the bearings were cooled with this mixture and the engines kept running until repairs were made to the pump, when everything was restored to normal operating conditions.

We have four 250-ton ice machines and two 1000-kw. generators and several turbines and vacuum pumps. Needless to say these must be kept running all the time and this mixture of ammonia is valuable.

C. E. Anderson.

Chicago, Ill.

QUESTIONS BEFORE THE HOUSE

A Convenient Safety Valve Chart

Mr. Carr's article in the Dec. 24 issue exemplifies graphically and in a very clear and ingenious manner the Massachusetts rule for safety-valve equipment. If, however, this rule is carefully analyzed, using Napier's law for the flow of steam through orifices as a basis, all as shown by Mr. Carr, but figuring still further to get the valve lift, the results in Table 1, showing the lifts which must be obtained in practice with valves having 45-deg. seats to discharge steam at the rate called for by the Massachusetts rule, are obtained.

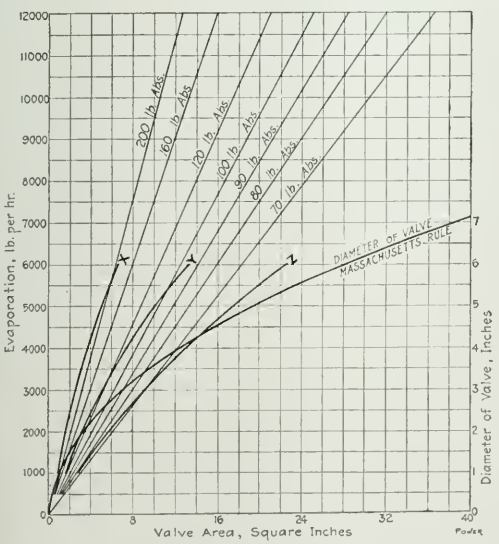
TABLE 1

Diam., in.	Lift, in.
2	0.067
3	0.100
4	0.133
5	0.167

TABLE 2

Diam., in.	Lift, in.
2	0.12
3	0.13
4	0.14
5	0.15

It may be noticed that this rule assumed the valve lift to be proportional to the diameter and also calls for lifts



SAFETY-VALVE CHART

considerably in excess of those found in almost all the well known makes of safety valves manufactured in this country at the present time.

In a certain line of safety valves now on the market, as made for stationary boilers, the lifts are about as shown in Table 2. Other makes, of which there are many in service, have the lift of the 4-in. valve as low as 0.01 in. and the great majority of 4-in. valves on the market today will show lifts less than 0.10 in.

Taking the line of valves in which the 4-in. size lifts 0.04 in., assuming that the lifts of the other sizes are graded about in the proportion of the actual lifts shown in Table 2, and figuring the valve diameters required, the line *X* was plotted on a reproduction of Mr. Carr's chart.

Proceeding in the same manner with a line of valves in which the 4-in. size lifts 0.08 in., the line *Y* was plotted, and using the lifts given for the valves in Table 2 in which the 4-in. valve lifts 0.14 in., the line *Z* was obtained.

As an example to show the practical working of this chart, assume an evaporation of 6000 lb. per hr., at 200 lb. absolute pressure. With the *Z* line of valves a 2½-in. diameter would be required, with the *Y* line a 3½-in. diameter and with the *X* line a valve 6 in. in diameter. The Massachusetts rule would be satisfied by a 3-in. valve.

For another example, take an evaporation of 5000 lb. per hr. at 100 lb. absolute pressure. The *Z* line would call for a 3½-in. valve, the *Y* line for a 5½-in. valve, the *X* line for two 5½-in. valves and the Massachusetts rule for one 4-in. valve.

In the preceding it is shown conclusively that the Massachusetts rule is safe, provided valves are selected which have lifts equal to or greater than shown in Table 1. Further, it is shown that the rules of the Board of Supervising Inspectors of Steam Vessels, the Canadian Steamboat Inspection Rules, the City of Philadelphia Rules, the State of Ohio Rules and the Massachusetts Rules would be much improved if they were revised to take into consideration the valve lifts. The objects of such rules are praiseworthy and are all steps in the right direction, but not until they are made safe and logical by introducing the element of valve lift will they correctly determine the requisite safety-valve equipment for all cases.

All of the above rules are now subject to criticism for the reason that it is very natural for the engineer in Massachusetts, for instance, to consider his safety valves adequate if they meet the requirements of the state law. He is liable to investigate no further, whereas if there were no such law he would probably study the subject carefully on his own account and also confer with the makers of the valves to find out their actual relieving capacity and compare it with his own data covering the maximum rate of steam production to be handled, thereby selecting valves of suitable size to take care of the maximum possible boiler evaporation.

F. C. BLANCHARD.

Bridgeport, Conn.

Boiler Scale

In the Oct. 29 issue, page 634, appeared a table giving the loss in boiler efficiency, due to the formation of scale, as determined by tests made by the engineering experimental station of the University of Illinois. The loss given varied from 7.2 per cent. for $\frac{1}{32}$-in. soft scale to 12.1 per cent. for $\frac{1}{16}$-in. soft scale.

The Bureau of Mines has a bulletin, No. 18, on "The

Transmission of Heat into Steam Boilers." This bulletin bases its conclusions both on tests made on small miniature boilers and on full-size models. No tests were made to determine the loss due to scale, but the following conclusion copied from this report may seem pertinent.

"The conductivity of metal forming the heating plate, even though the plate has a moderate amount of coating, is so high that any amount of heat that can be imparted to the dry surface by convection, can be transmitted through the heating plate without difficulty. Water has such high heat-abstracting ability that it can absorb heat as fast as the heating plate is able to conduct it. The slowness of the process of heat transmission into a boiler is due to the slowness with which heat, in present practice, is imparted to the dry surface."

The discrepancy in the conclusions drawn by two such excellent authorities seems to at least warrant discussion.

A review of the paper by the experimental station discloses several facts:

Its first series of tests was made on a locomotive boiler and the rate of combustion was higher than is generally at present used in stationary practice. In the three later tests made on single tubes only, the length of tubes is not given so that the rate of heat conduction cannot be computed. The water was raised in temperature from approximately 65 deg. to 112 deg. The conditions in these three tests are entirely different from actual conditions in a steam boiler. In a steam boiler, steam bubbles forming on the heating surface and rising, leave room for more water to reach the hot surface, thus causing a constant circulation inside the tube and this aiding in carrying off the heat from the plate. The great variations in the results are also worthy of note.

The Bureau of Mines gives the following formula for heat conduction:

$$H = \frac{C}{d}(T_1 - T)$$

Where

H = Quantity of heat transmitted per unit area of heating plate:

C = Average conductivity;

For iron the bureau gives 0.0005 for 1 in. thick.

d = Thickness;

T_1 = Temperature of dry surface;

T = Temperature of wet surface.

At the rate of 10 sq.ft. of heating surface per boiler horsepower, the heat transmitted per square inch per hour is:

$$\frac{34.5 \times 965\,*}{10 \times 144} = 23.1 \text{ } B.t.u. \text{ } per \text{ } sq.in. \text{ } per \text{ } hr.$$

or

$$\frac{23.1}{60 \times 60} = 0.0064 \text{ } B.t.u. \text{ } per \text{ } sq.in. \text{ } per \text{ } sec.$$

Transposing the formula of the Bureau of Mines for heat transformation we have,

$$T_1 - T = \frac{d \times H}{C}$$

This gives us a heat difference in this case of

$$\frac{0.1 \times 0.0064}{0.0005} = 1.3 \text{ } deg. \text{ } F$$

*Marks and Davis give 970.4 as the latent heat of evaporation from and at 212 deg.

Dr. Joseph G. Rogers, in a paper read before the American Association for the Advancement of Science, gives the heat conductivity of scale as compared to iron in the ratio of 1:37.5.

This gives us the heat conductivity of scale as

$$\frac{0.0005}{37.5} = 0.00001333+$$

Assuming a ring of scale of the same dimensions as for the iron pipe, we would have a temperature difference of

$$\frac{0.1 \times 0.0064}{0.00001333} = 48 \text{ } deg.$$

With both pipe and scale we should then have a temperature drop through the combined surface of approximately 50 deg.

Assuming the following values for an actual boiler and using the formula

$$E = \frac{T - t_f}{T - t_s}$$

where

E = True boiler efficiency;

T = Initial temperature of gas entering the boiler;

t_f = Temperature of air leaving the boiler;

t_s = Temperature of the steam.

T assumed at 2500 deg. F.

T_f assumed at 600 deg. F.

T_s assumed at 350 deg. F.

For a clean boiler we would then have a true boiler efficiency of

$$E = \frac{2500 - 600}{2500 - 350} = \frac{1900}{2150} = 88.37 \text{ } per \text{ } cent.$$

With scale in the tube the drop will become about 50 deg. more than in the clean tube and it seems fair to assume the temperature of the gas leaving the boiler would be 50 deg. hotter or 650 deg.

Our efficiency for the scaled tube would then be

$$E = \frac{2500 - 650}{2500 - 350} = \frac{1850}{2150} = 86.4 \text{ } per \text{ } cent.$$

This gives us a drop in efficiency of only 2 per cent., which certainly is considerably less than that given by the University of Illinois.

Is it not a case of poor conductivity at the joint of scale and iron which causes this discrepancy? The great variation in figures obtained might be due to the different composition of the different scales. The figures also seem to show very little additional loss as the thickness of scale is increased.

It would seem as though a test upon artificially made scale, the composition of which is known, might throw considerable light on the subject.

JOHN BAILEY.

Milwaukee, Wis.

The use of steam-turbine-driven centrifugal pump units to carry the peak of the load in water-works pumping stations is exemplified in the new water-works of Youngstown, Ohio. It is stated that contracts were let on Dec. 14 for two 7,500,000-gal. pumping units for the new pumping station at Youngstown. One contract was for a triple-expansion reciprocating pump, let to the William Tod Co., of Youngstown, at a price of $72,110, for a pump with a guaranteed duty of 163,000,000 ft.-lb. A contract was also let to the Kerr Turbine, with a guaranteed duty for the unit of 80,000,000 ft.-lb.

INQUIRIES OF GENERAL INTEREST

High- and Low-duty Pumps—What is the difference between a high- and a low-duty pump?

K. N. F.

The ordinary steam pump taking steam during the full stroke is called a low-duty pump. Formerly, a high-duty pump was always understood to be one of crank and flywheel type; but now, some prefer the definition that a high-duty pump is any pump that uses steam expansively.

Vapor Pipe Use—What is the advantage of having a vapor pipe connected with the suction pipe from a feed pump to an open heater?

K. F. N.

A vapor pipe in a pump suction from an open heater prevents a part vacuum and reduction of pressure in the suction pipe which would result in the release of vapor, thereby causing the pump to slip the same as though there were air in the pipe.

Removing Oil Stains—How can oil stains be removed from walls and floors?

H. E. R.

Grease spots can be drawn out of floors by covering them with powdered magnesia, and out of walls or ceilings by covering the spots with a thick paste of magnesia and water, subsequently removing the magnesia. Surface spots can be removed by any alkali wash, such as water containing ammonia, wood ashes, soda, potash or any alkali that will not injure the material to be cleaned.

Crosshead Alignment—How can the alignment of a crosshead shoe be tested?

N. F. K.

Loosen the piston-rod packing and, starting with the piston at the head end of its stroke, observe whether the gland is moved laterally as the crosshead is moved to the opposite end of the stroke. The direction of the movement of the gland, if it moves at all, indicates the direction in which the crosshead shoes are out of line. Correct for one shoe and then the other until the above test shows no movement of the gland.

Home-made Pipe Covering—Will a mixture of sawdust and flour make a satisfactory pipe covering? Is there any other cheap covering?

C. N. T.

A mixture of flour paste and sawdust should make a fairly good covering for steam pipes; but it probably could not be applied and held properly in place without first wrapping the pipe with wire cloth for a foundation. The effectiveness of the covering would depend on the porosity or proportion of air-cell spaces in the covering.

A very good cheap covering is made up of unsized building paper, after first covering the bare pipe with asbestos paper, and there should be a final covering of asbestos paper to prevent the covering from taking fire or communicating it to combustible materials in its vicinity.

Belt Power—With the same widths of belts, the arcs of contact the same and the belts running at the same speed in feet per minute, does it make any difference in the power transmitted by the belts whether the pulleys are 3 ft. or 6 ft. in diameter? Does the increased area of contact on the larger pulley give the belt a better grip so that it would transmit more power? Does the increased leverage on the larger pulley make the belt more powerful?

T. T.

Under the conditions named in the first question, the same horsepower would be transmitted irrespective of the diameter of the pulleys. The number of degrees in the arc of contact, and not the area of contact, is the determining factor, for friction is directly as the total pressure and independent of the area.

Increased leverage does not come into the question or rather is taken into account when it is assumed that the same number of feet per minute is traveled whether the pulleys be large or small.

Water Pressure Helps Pump—Why is it that a pump having steam and water cylinders of the same diameter can, nevertheless, deliver water into the boiler from which it takes its steam supply, the boiler pressure being 110 lb. and the city water pressure 85 lb.?

W. A. O.

The inlet pressure of the water assists in the water end of the pump, making that part, to an extent, a water engine, so that the steam end, theoretically, has to overcome only the difference between 110 lb. and 85 lb., or 25 lb. Practically, this pressure is somewhat greater, due to the friction of the pump parts and the water, etc., which has the effect of increasing the pressure to be pumped against.

Net Lift of Vacuum Pump—A wet vacuum pump is placed so that its cylinders are 4 ft. below the water level (maintained by a float) in the surface condenser from which it draws. It discharges into an open tank at such a height that a gage on the delivery pipe at the level of the cylinders shows 5 lb. pressure. If the vacuum in the condenser is 28.2 in., what is the equivalent total lift in feet through which this pump works?

F. J. P.

In creating a vacuum of 28.2 in., a pump does the equivalent of lifting water a height of

$$28.2 \times 1.132 = 31.92 \text{ ft.}$$

1.132 ft. being the head in feet of water corresponding to 1 in. of mercury. But 4 ft. of this head is due to the water itself so that the net lift of the pump is

$$31.92 - 4 = 27.92 \text{ ft.}$$

The discharge head corresponding to 5 lb. is

$$5 \times 2.309 = 11.55 \text{ ft.}$$

2.309 ft. being the height of a column of water giving a pressure of 1 lb.

The total net lift, therefore, is

$$27.92 + 11.55 = 39.47 \text{ ft.}$$

Centrifugal Pump Horsepower—A centrifugal pump, furnishing salt water for a condenser, has a horizontal shaft, the center of which is 9½ ft. above the water in the intake. A gage, on the delivery pipe, 4 ft. above the shaft, reads 7 lb. If the pump delivers 37,000 cu.ft. per hour and its mechanical efficiency is 55 per cent., what horsepower does it take to drive it?

P. J. F.

From the intake level to the position of the gage, the pump lifts the water

$$9.5 + 4 = 13.5 \text{ ft.}$$

Salt water weighs about 64 lb. per cu.ft., which is also its pressure per square foot for each foot of head.

$$\frac{64}{144} = 0.444 \text{ lb.}$$

will, therefore, be the pressure per square inch per foot of head, and the total to the level of the gage,

$$13.5 \times 0.444 = 5.994 \text{ lb.}$$

The pressure in the discharge pipe being 7 lb., the total head is

$$5.994 + 7 = 12.994 \text{ lb. per sq.in.,}$$

or

$$12.994 \times 144 = 1871.136 \text{ lb. per sq.ft.}$$

In 1 min. there is pumped,

$$\frac{37{,}000}{60} = 616.666 \text{ cu.ft.}$$

and against a pressure of 1871.136 lb. per sq.ft., the work done is

$$616.666 \times 1871.136 = 1{,}153{,}865.953 \text{ ft.-lb. per min.,}$$

which corresponds to

$$\frac{1{,}153{,}865.953}{33{,}000} = 34.965 \text{ hp.}$$

But, as the pump efficiency is only 55 per cent., the actual power required is

$$\frac{34.965}{0.55} = 63.57 \text{ hp.}$$

ENGINEERS' STUDY COURSE

Mensuration—Part II

Quadrilaterals

A plane is a flat surface like that of a piece of sheet packing, or the floor, or the wall of the engine room. The edges of a plane figure may be straight or curved. A *quadrilateral* is a plane figure bounded by four straight lines, but the lines do not necessarily have to be parallel lines.

A *parallelogram* is a quadrilateral whose opposite sides are parallel. A *rectangle* is a parallelogram, all of whose angles are right angles as in Figs. 1 and 2.

All figures have a *base,* which is the underside or side on which the figure stands. The *altitude* of a figure is

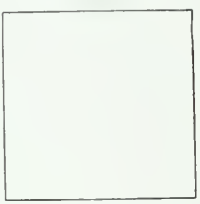


Fig. 1.

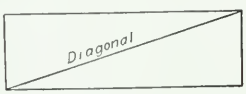


Fig. 2.

Fig. 4.

Fig. 5.

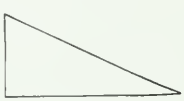


Fig. 6.

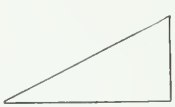


Fig. 7.

Fig. 8.

its height or the distance between the base line and the top; in a parallelogram, the altitude is the distance between the top and bottom parallel lines.

Rule: *To find the area of any parallelogram, multiply the base by the altitude.*

This rule is seen to be true by studying Fig. 3, which is a plane figure 12 in. long and 6 in. wide. Applying the rule to it, we have

$$12 \times 6 = 72 \ sq.in.$$

You can prove that this rule is correct by simply counting the number of squares which you will find to be seventy-two. We see that this rule is correct for a rectangle as well as a square.

If we know the area and either the base or the altitude of a parallelogram, we can easily find the unknown dimension.

Rule: *Divide the area by the given dimension to get the unknown dimension.*

Example: A rectangular cooling pond has a surface area of 37,944 sq.ft. If the pond is 204 ft. long, how wide is it?

$$Area = 37{,}944 \ sq.ft.$$
$$Length = 204 \ ft.$$
$$\frac{37{,}944 \ sq.ft.}{204 \ ft.} = 186 \ ft. = width$$

Example: How many square yards of asbestos will be required to cover a rectangular feed-water heater 8 ft. high, 5 ft. wide and 5 ft. long

$$\frac{8 \times 5 \times 4 \ (sides) + (5 \times 5)}{9} = 20.56 \ sq.yd.$$

Here we divided the total area of the sides and top by 9

Fig. 3.

because our answer is to be in square yards, and 9 sq.ft. equals 1 sq.yd.

Triangles

A *triangle* is a plane figure having three sides.

A *right-angled triangle* is any triangle containing a right angle.

By drawing a *diagonal* through the rectangle, Fig. 2, we produce two right-angled triangles. Other such triangles are shown in Figs. 6, 7 and 8.

An *isosceles triangle* is one having two of its sides of equal length, as Fig. 4.

An *equilaterial triangle* is one having its three sides equal in length, as Fig. 5.

One of the interesting things about triangles is that the sum of all three angles will equal 180 deg., or two right angles. Thus, studying the angles in the triangles, Figs. 2 to 8, we find that the sum of the angles of each triangle equals two right angles.

In a right triangle, which is a shorter name for a right-angled triangle, the side opposite the right angle is called the *hypothenuse.* The sides forming the right angle form the base and altitude.

If you will study Fig. 9, you will see that the sum of the squares of the sides forming the base and altitude is equal to the square of the hypothenuse. As this relation between the base and the altitude and the hypothenuse is always true of a right triangle, we can easily find the length of one side of a right triangle when two sides are known. We can also easily produce formulas for calculations involving the right triangle. Let

A = Altitude;
B = Base;
C = Hypothenuse.

We have these formulas for the right triangle.

$$A = \sqrt{C^2 - B^2}$$

$$B = \sqrt{C^2 - A^2}$$

$$C = \sqrt{A^2 + B^2}$$

Example: A steel stack 50 ft. high is to be mounted on a base, the height of which is 4 ft. from the ground. Three feet from the top of the stack is a ring to which six guy cables or wires are to be fastened to hold the stack. Each cable is to be fastened to piers located 30 ft. along the ground from the stack. Allowing 2 ft. to each cable

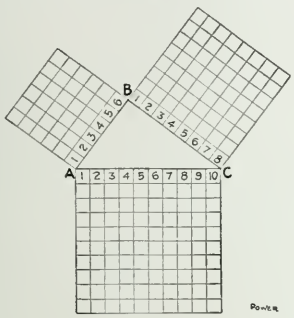


Fig. 9.

for fastening, how many feet of cable will be necessary to support the stack?

Here the guy cables form the hypothenuse. The base is 30 ft. and the altitude is

$$50 - 3 + 4 = 51 \text{ ft.}$$

Applying the formula for finding the hypothenuse

$$C = \sqrt{51^2 + 30^2} = 59.16+ \text{ ft.}$$

Adding 2 ft. for fastening

$59.16 + 2 = 61.16 +$ *ft. = length of cable needed for one guy*

Then there will be

$61.16 \times 6 = 366.96$, say 367 *ft.*

of cable needed to complete the job.

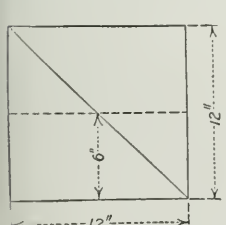


Fig. 10.

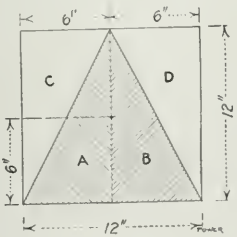


Fig. 11.

Suppose we have a rectangle as in Fig. 10, the area would be

$$12 \times 12 = 144 \text{ sq.in.}$$

If it is divided in half, as by the dotted line, the total area will, of course, be divided in half. If a diagonal is drawn, forming the two right triangles, the area is divided into two equal parts. If instead of drawing one diagonal, we make two, one in each half of the square, forming four right angles, *A*, *B*, *C* and *D* respectively, Fig. 11, all the triangles will be of equal area and the shaded triangles, *A* and *B*, will be equal in area to the two unshaded ones, *C* and *D*.

A little study of these triangles will show that a simple rule may be written for finding the area of a triangle. Consider the half of a rectangle containing the triangles *A* and *C*, Fig. 11. The dotted line across this rectangle divides it into two smaller rectangles, each 6x6 in., or 36 sq.in. in area. For the present, consider only the rectangle containing the triangles *A* and *C*. The area of this rectangle is

$$12 \times 6 \text{ in.} = 72 \text{ sq.in.}$$

We can now see that the shaded part of *A* above the horizontal dotted line, will exactly fill the unshaded part of *A*, the lower left rectangle. Also the shaded part, *A*, will just fit into the unshaded part, *C*.

Now, as the area of the left rectangle is 72 in. and as it is divided into two triangles of equal areas, the area of each triangle must be $\frac{72}{2} = 36$ sq.in.

Rule: *The area of a triangle is found by multiplying the base by one-half the altitude.*

Applying the rule to the triangle *A*, we have

$$\text{Area} = \text{base} \times \frac{\text{altitude}}{2} = 6 \times 6 = 36 \text{ sq.in.}$$

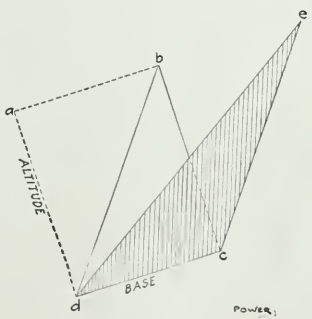


Fig. 12.

This rule may also be expressed

$$\text{Area} = \frac{\text{base} \times \text{altitude}}{2}$$

Example: An ash hopper, shaped like an inverted pyramid, is to be made up of four triangular pieces of steel plate, each with an 8-ft. base and a 10-ft. altitude. How many square feet of plate are required and what must be the length of each of the four angle-irons to which the sheets are to be riveted? Nothing is to be allowed for the space which the gate will occupy.

The total area of the four plates will be

$$\frac{8 \times 10}{2} \times 4 = 160 \text{ sq.ft.}$$

The length of an angle-iron for one side will be (see formula for finding the hypothenuse of a triangle)

$\text{Hypothenuse} = \sqrt{10^2 + 4^2} = 10.77$ *ft. = length of one angle iron*

The rule

$$\text{Area} = \frac{\text{base} \times \text{altitude}}{2}$$

is also true for a triangle like *A* in Fig. 12. Assume the

base *de* of the rectangle *abcda* to be 12 in. and the altitude 16 in. Then the area of the triangle *dbcd* is

$$Area = \frac{12 \times 16}{2} = 96\ sq.in.$$

The shaded triangle *decd* has a base *dc*, which is 12 in., the same as in the triangle *dbcd*. As the altitude of any triangle is the length of a line drawn *perpendicular from the apex to the base*, the altitude of the triangle *decd* will be 16 in. or the same as for the triangle *dbcd*; consequently the area will be

$$Area = \frac{12 \times 16}{2} = 96\ sq.in.$$

which is the same as the area of the triangles *dabd* and *dbcd*.

To find the altitude or base of a triangle when the area and base or altitude are given:

Rule: *Double the area and divide by the given dimension.*

Example: A lot shaped like a right triangle is 57,607 sq.ft. in area and is used for storing coal. The base of the triangular lot is 157 ft.; what is the altitude?

(b) How many lineal feet of 12-in. wide boards are necessary to inclose the lot with a solid fence 12 ft. high, allowing a doorway 11 ft. wide for the passage of coal cars?

The altitude is

$$\frac{57{,}607 \times 2}{157} = 733.847\ ft.$$

The length of the hypothenuse would be

$$\sqrt{733.847^2 + 157^2} = 750.45\ ft.$$

The length of fence is

$$750.45 + 733.847 + 157 = 1641 + ft.$$

The number of lineal feet of lumber required is

$$(1641 - 11) \times 12 = 19{,}560\ ft.$$

For practice, the student should work out all the examples given in this lesson. Many new examples can readily be found, as the triangle is involved in many practical problems.

Answers to Last Week's Problems

(1) (a) 2.067. (b) 4.134.
(2) An acute angle.
(3) 11,160.

⁂

The Current-O-Scope—Such is the name given to a little celluloid novelty brought out by Fairbanks, Morse & Co., Chicago, to illustrate the action of an induction motor. The whole device is only about 3 in. square and goes in a little flat leather envelope. The device itself is somewhat like numerous calculating charts of various kinds that have been brought out, so far as its construction is concerned, but is entirely different in all other respects. On the face of the chart is the representation of the cross-section of an induction motor with the stator and rotor windings shown. In the center is a vector diagram, which shows the manner in which the current varies in the three different phases, which latter are represented as red, green and black for purposes of distinguishing them. At other openings in the chart are arrows showing the direction of the currents in the lead wires, and other marks show the direction of the current through the various parts of the windings as well as the strength and direction of the magnetic field. With the device is a little instruction book concerning its use. Altogether it is a very ingenious means of demonstrating the current action in an induction motor, and is well worth the price of 25c., which is being asked for it.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Men of the ancient Egyptian upper crust, says an Egyptologist, "commonly lived to be 110 years old. They consumed 100 jars [Egyptian for 'can'?—Editor] of beer daily and had their wives tickle their feet." According to this theory, a centipede, with its choice collection of feet, should live 5500 years. While we are tickled that the Egyptians had their feet tickled, we are jarred somewhat by that beer-consumption feat. The last Metropolitan Museum Egyptian we saw looked like he'd drunk himself black in the face. He looked jarred, or pickled, not tickled.

⁂

If you were asked to name offhand ten famous men in the history of steam engineering, whom would you say and in what order? Dig up a postcard and send your list to "Power."

⁂

Lincoln Boffum, who is doing the pumping for our village water supply out on the meadows, is grinning yet over how he kidded a city chap who was out that way shooting hare. The city fellow was tearing round in circles when he spied Link coming across the yard with a barrow of coal, and rushing up, hollered:

"Say, you; I lost my hare. Seen it?"

Link kind of snickers. Then pulling off his cap, and displaying one of the highest foreheads in Harris County, drawls out:

"I lost all of mine, and I ain't makin' the fuss you be."

⁂

One of J. P. Morgan's partners says that there is no such thing as a money trust; it's a spectre. Now we know why on pay-day folks ask: "Has the ghost walked yet"? This ghost exhibits the right spirit usually and he (or it) can't walk too often to suit us.

⁂

Even if we have no money ourselves, we like to talk about it. Here's another. The Union Electric Light & Power Co., St. Louis, loans money to its needy employees who might, otherwise go to the loan sharks. This succor by the company saves the other suckers from being badly bitten by the sharks, and, as Old Cap'n Prouty, down Cape Cod way, used to say, "Sharks is h-ll!" (You'll have to guess at the missing letter).

⁂

Continuing, how would you like to earn a hundred thousand dollars in real money? You can if you know a better fuel than gasoline for an internal-combustion engine. All Europe and the United States (except possibly Dooley's friend, Jawn D.) are ready to make you rich when you get the answer.

⁂

Here's another money hunch. Dr. Hodge, Niagara Falls, N. Y., offers to pay a thousand dollars to anyone who will give him one good reason for the habitual use of tobacco. As the New York Fire Commissioner has josjohnsoned our chances of smoking in this office, we hereby offer $2000 for a good excuse for breaking this law. The money will be cheerfully paid out of our next week's wage—er, salary.

⁂

A distinguished Frenchman in our midst says he cannot give an offhand formula for the significance of laughter. That we should become apprehensive! We can laugh, even take a smile, and usually we don't care one of those little tinker things what we laugh at either—but the "smile" must be good. Ding bust the reason, always excluding the sneer and the venom. Let's live to laugh and laugh to live. If you're just "folks," laugh and grow content; if you think you're "somebody," relax occasionally and let dignity go hang!

⁂

Friend Stone, over to Boston, has mortared and pestled these little tablets for our mental digestion and to give publicity to the Elliott Power & Accessories:

"Success Comes in Cans. Failures in Can'ts!"

"Brains Never Swell the Head."

"Seek, and Ye Shall Find; Knock and Nothing Shall Be Opened Unto You!"

The Mixed Pressure Steam Turbine

SYNOPSIS—Description of a mixed-pressure turbine being put out by the British Thomson-Houston Co. in which the high-pressure and low-pressure steam is conducted through separate nozzles in the second stage. The general governing features of mixed-pressure turbines are also discussed.

In a paper on the "Development in Curtis Steam Turbines," read recently before the Manchester Association of Engineers, R. F. Halliwell devotes considerable space to the mixed-pressure type and describes the latest practice of the British Thomson-Houston Co. in this respect. His remarks were in part as follows:

In mixed-pressure turbines the low-pressure steam is generally admitted to an intermediate stage where it mixes with steam which has already done work in the high-pressure stage. In many cases, however, where the utmost economy under high-pressure conditions is not essential, a special high-pressure stage is not employed, the high-pressure steam and low-pressure steam both being admitted to the same first-stage wheel, of course, through separate nozzles, the two supplies of steam not mixing until both have done work in the first stage. This arrangement presents many advantages, inasmuch as the utilization of the low-pressure steam available is not affected by the quantity of high-pressure steam which is being admitted to the turbine.

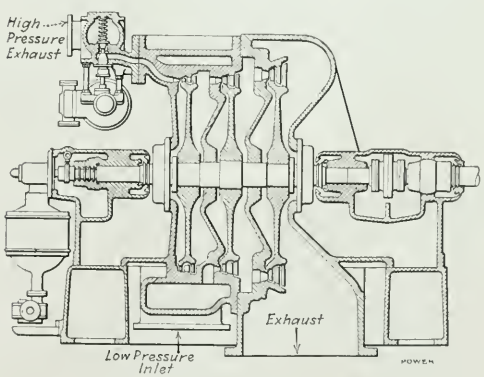
The same cannot be said of the ordinary mixed-pressure turbine, with a separate high-pressure stage, in which the low-pressure steam mixes with the already partially utilized high-pressure supply, the two together passing through common nozzles to the second stage. In this case, since the second-stage nozzles have to be designed to pass a certain maximum quantity of steam at the low-pressure inlet pressure, if from any cause the amount of high-pressure steam being used is larger than that allowed for, the quantity of low-pressure steam which can pass through the nozzles will be correspondingly reduced, with the effect that the turbine is incapable of utilizing its full quantity of low-pressure steam, although there may be an ample supply available.

The great advantage of having separate low-pressure inlet nozzles will therefore be apparent, but in order that the pressure in the second stage may not affect the flow of steam through the first-stage nozzles, it is necessary that the second-stage pressure be not greater than about 58 per cent. of the first-stage pressure, that is, the critical point below which the weight of discharge through a nozzle is independent of the discharge pressure and depends solely on the initial pressure. To be well on the safe side of this critical point it is necessary that a considerable proportion of the energy be utilized in the first low-pressure stage, the Curtis turbine being practically the only one which permits this to be done without loss of efficiency. With the reaction type in which steam is admitted around the whole circumference, this arrangement is impossible.

The British Thomson-Houston Co. has recently patented and are now building a new type of mixed-pressure turbine, shown in the illustration, in which the advantages mentioned are combined with excellent economy on high-pressure steam. This turbine has a separate high-pressure stage, the steam from which, instead of mixing with the low-pressure steam and then passing to the second stage goes into separate nozzles in the second stage, the two supplies not mixing until they have passed through the second stage. Owing to the provision of special nozzles in the second stage to receive the partially utilized high-pressure steam, these nozzles can be designed to suit high-pressure conditions.

It should be noted that when this turbine is operating with low-pressure steam alone, the pressure in the space surrounding the high-pressure wheel is only that found at the entrance to the third stage, which being quite low produces small rotation losses, so that the loss in efficiency as a low-pressure turbine is small.

This design of turbine has been criticized because when operating under mixed-pressure conditions with a quantity of low-pressure steam below the normal, the inlet pressure of the low-pressure steam is lower than it would be if the pressure were kept up by the admixture of the high-pressure steam which is being used, and that therefore the low-pressure steam consumptions suffer. It would certainly seem that to claim an advantage for the maintenance of pressure in an ordinary mixed-pressure turbine, due to the admission of high-pressure steam, is in the nature of making a virtue of a necessity, and that any slight theoretical gain in economy under certain abnormal conditions is more than counterbalanced by the ability to utilize at all times the full quantity of exhaust steam. Also in the case of turbines working with regenerative accumulators, the reduction in pressure as the quantity of low-pressure steam decreases permits full advantage to be taken of the regenerative capacity by using an automatic shutoff valve on the far side of the accumulator.



SECTION THROUGH THOMSON-HOUSTON MIXED-PRESSURE TURBINE

In the British Thomson-Houston mixed-pressure turbines the low-pressure controlling valve, which is usually of the butterfly type, is operated by a bell crank actuated by a spiral cam at the end of the camshaft. The cams are arranged so that the first high-pressure valve is not opened until the low-pressure valve is wide open, so that so long as there is sufficient low-pressure steam to deal with the load no high-pressure steam is used.

In many cases where mixed-pressure turbines are operated in electrical connection with reciprocating engines, from which the low-pressure steam is obtained, no controlling valve for the low-pressure steam is fitted, or if fitted is rendered inoperative by the turbine being kept to speed through the interlocking of the engine and turbine generators, and utilizing all the exhaust steam available. High-pressure steam can be admitted when dealing with heavy loads by adjusting the synchronizing gear, so that if left to itself the turbine would run a little slower than the normal speed of the station. In this way the turbine governor will only come into operation when the total load is such as to cause the station speed to drop a certain amount below the normal. A set of 3000 kw. capacity has been recently supplied to the Lancashire & Yorkshire Ry. for their Formby station.

Another method of governing mixed-pressure turbines, when the turbine receives the exhaust from an engine or engines not electrically connected with the turbine, is to arrange the low-pressure controlling gear to operate a bypass either to a lower stage or to the condenser. By this means, should the quantity of exhaust steam be more than sufficient for the load on the turbine, the bypass opens, and reducing the back pressure on the engine, enables it to do its work with less steam, the quantity of which is readjusted by the engine governor. With this arrangement the back pressure on the engine, and consequently the quantity of steam used by the engine is kept down to the minimum required for the load on the turbine, and maximum combined efficiency is thereby obtained.

Where mixed-pressure turbo-alternators run in parallel with high-pressure sets of similar or larger size, it becomes necessary to slightly modify the governor gear to permit a proper distribution of load to be secured in the event of a partial or complete cessation of the low-pressure supply. This is easily and simply provided for by a duplex arrangement of the pilot valve regulating the oil supply to the servo motor. The valve itself, which remains as before, is surrounded by a sleeve or hollow outer valve, actuated by a piston exposed to the low-pressure inlet pressure in such a way that if this inlet pressure falls the position of the ports admitting oil to the servo motor is altered; also the camshaft is rotated sufficiently to admit enough high-pressure steam to deal with the load without the governor being affected, and therefore without any change in speed. Restoration of the low-pressure inlet pressure results in the replacing of the parts in their original positions.

❖ ❖

On Figuring the Indicated Horsepower

By Julian C. Smallwood

SYNOPSIS—The author demonstrates that unless the area of the diagram from one end is three times that of the diagram from the other, less than one per cent. of error is incurred by using the average diagram and piston areas in computing the horsepower. He also gives a formula for setting an adjustable planimeter so that it will read directly in terms of horsepower.

❖

When using the formula

$$I.hp. = \frac{PLAN}{33{,}000}$$

for a mathematically exact result, it is necessary to calculate separately the horsepowers on the two sides of the piston of a double-acting steam engine and add them together to get the total horsepower. This is because the area on the crank end is less than that on the head end by the amount of the piston-rod cross-section. The steam-engine code of the A. S. M. E. recommends that the average mean effective pressure and the average area be used in the formula so that the result may be obtained by a single computation, N then signifying the number of strokes instead of the number of revolutions. The code further states that where extreme accuracy is required, the first mentioned method may be used; but it does not say how much error may be involved by not using it nor under what circumstances the error may be excessive.

A brief consideration will show that the more nearly is the area on the crank end equal to that on the head (that is, the smaller is the area of the piston rod relative to that of the cylinder), the less error is there in the approximate calculation. Also, the less difference is there between the mean effective pressures on the two sides of the piston, the less error is there. When they are equal, the results from the two methods are the same

The following is a rational formula by which the per cent. of error ensuing from the approximate method may be determined for any conditions.

Let

R = Ratio of the m.e.p. on the crank end to the m.e.p. on the head;

d = Diameter of the piston rod, inches;

D = Diameter of the cylinder bore, inches.

Then

$$Per\ cent.\ of\ error = 50 \times \frac{d^2}{D^2} \times \frac{1 - R}{1 + R}$$

As an example, let $d = 2$ in., $D = 10$ in., and $R = 3$. Then

$$Per\ cent.\ of\ error = 50\tfrac{4}{100} \times \frac{1 - 3}{1 + 3} = 1\%,\ minus$$

It is hardly worth while, because of instrumental errors, to calculate the result closer than to 1 per cent. of error, so we may conclude that under these conditions if the mean effective pressure on one end is less than three times what it is on the other, the approximate calculation is sufficiently accurate. It is apparent, too, that with any engine with a valve setting giving fair division of the load, so that the mean effective pressures are reasonably equal, there is entirely negligible error from the approximate method. With some engines the cylinder work may be fairly divided at normal loads, but at light loads quite unequally so. In such cases the formula will show whether or not the correct method should be used. A convenient rule following from the formula is as follows:

If the mean effective pressure on one end is not greater than

$$\frac{50\,d^2 + D^2}{50\,d^2 - D^2}$$

times the mean effective pressure on the other, then the error is less than 1 per cent.

Taking advantage of the approximate method, the indicated horsepower of a steam engine may be readily obtained by a direct reading of a polar planimeter without calculation, provided the planimeter has an adjustable arm. It is merely necessary to adjust the length of this arm (namely, the distance between the tracing point and the pivot of the planimeter), according to the result obtained by the following formula:

Let

C = Desired length of the adjustable arm, inches;
l = Length of the indicator diagram, inches;
S = Scale of the indicator spring;
K = Product of LAN in the $PLAN$ formula: L in feet, A the average of the two areas, square inches, N the r.p.m.;
w = Diameter of record wheel, inches;
G = Number of graduations on the record wheel;
X = Number of graduations selected to read one indicated horsepower.

Then

$$C = \frac{10{,}500\ l\ G}{S\ K\ w\ X}$$

With the adjustable arm set to equal the calculated length C, the i.hp. is read directly from the record wheel according to the selected scale X, after traversing the

Fig. 1. Hood Removed, Showing Accessibility of Valve

head and crank-end diagrams in the usual way to obtain area.

As an example, take a 10x16 engine at 160 r.p.m., having a $1\frac{7}{8}$-in. piston rod. The indicator diagrams are 3.25 in. long and the scale of the indicator spring is 60 lb. to the inch. The planimeter has a record wheel 0.79 in. in diameter bearing 100 graduations. A vernier subdivides each graduation into tenths so that if one graduation on the wheel equals one horsepower, the results may be read to one-tenth of a horsepower. Hence a convenient value of X is 1. The area on the head end is 78.5, on the crank is 76.9 sq.in., and the average area is 77.7 sq.in. Now,

$$K = \tfrac{16}{12} \times 77.7 \times 160 = 16{,}576$$

$$C = \frac{10{,}500 \times 3.25 \times 100}{60 \times 16{,}576 \times 0.79 \times 1} = 4.34\ in.$$

For obtaining the results during the progress of a test, this method will be found very convenient as it saves the time and labor of slide-rule work without impairing arithmetical accuracy. The indicators should give a constant length of diagram equal to that used in the calculation for C. An average value of the r.p.m. is used in the formula for C. If the speed changes, the arm C may be readjusted to a new length equal to that first calculated multiplied by the ratio of the first to the second number of revolutions per minute.

❖

Boylston Improved Steam Trap

The Boylston improved steam trap, illustrated herewith, is designed with especial view to accessibility and low maintenance cost. By using a reversible valve seat doubly long life is given to that important part of the apparatus. The disk can be removed by lifting the valve hood, Fig. 1, which exposes the disk, and taking out the

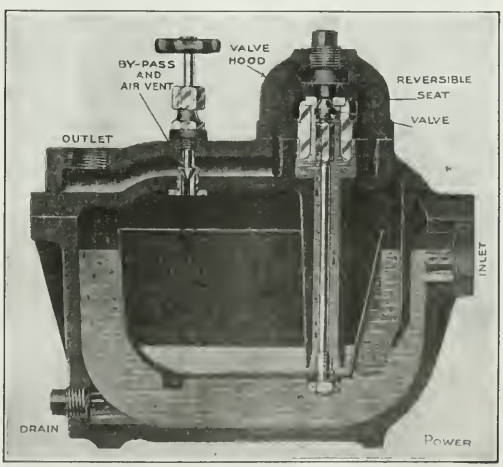


Fig. 2. Sectional View through Trap

small pin which fastens the disk to the stem. The seat can be removed from the hood by taking out the brass bushing which holds it in place.

Another feature is the built-in bypass and air-vent valve, Fig. 2. With this arrangement extra piping, fittings and labor are saved.

Due to the fact that the valve stem is anchored close to the bucket hinge, producing thereby maximum leverage, it is possible to use a valve of unusually large area and, hence, obtain large capacity.

This trap is manufactured by the Western Kieley Steam Specialty Co., 116 West Illinois St., Chicago, Ill.

Developments in Oil Burning*

By E. H. Peabody

SYNOPSIS—Methods of introducing air to secure proper mixture with the oil spray. Principal oil-burning systems installed in torpedo-boat destroyers.

Air Distributors

Great delicacy is required in introducing the air for combustion, very slight changes affecting the results in unsuspected ways, and while almost any method may result in smokeless combustion, maximum economy and capacity can only be secured by careful and intelligent design.

It is not necessary to give the air a whirling motion but, judging from rather exhaustive experiments, better gas analyses are secured, lower air pressures are required, and less refinement of adjustment is needed if the air is brought into contact with the oil spray with the right sort of a twist. We have found the impeller plate illustrated in Fig. 9 most effective in accomplishing this mixture, and most satisfactory results have been obtained with it.

Fig. 10 shows a cast-iron truncated cone, with slots cored in the side so arranged as to give the air a whirling motion. It was tried with the end closed and all the air passing through the slots, and also with the end open, some of the air passing through the slots and some through the end of the cone around the burner. The burner was located at the end of the cone as shown in the cut, and also pushed into the inner end of the cone, and also in intermediate positions. The whirling motion of the air obtained with this arrangement is of a different character from that obtained with the impeller plate.

Fig. 11 shows truncated cones made up of concentric

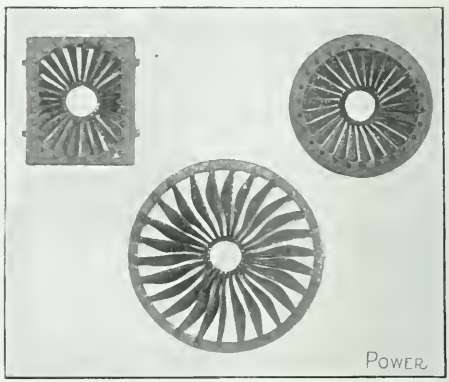


Fig. 9. Impeller Plates

rings of sheet iron with air passages between them, and so formed as to direct the air toward the axis. The angle of one set of rings was 71½ deg. and that of the other set, 15 deg. from the axis. There was no whirling motion.

Fig. 12 shows a truncated cone of sheet iron with no air openings in the side but at both ends, as shown by the arrows. No whirling motion resulted. Fig. 13 illustrates a flat disk or plate of sheet iron placed on the fire-

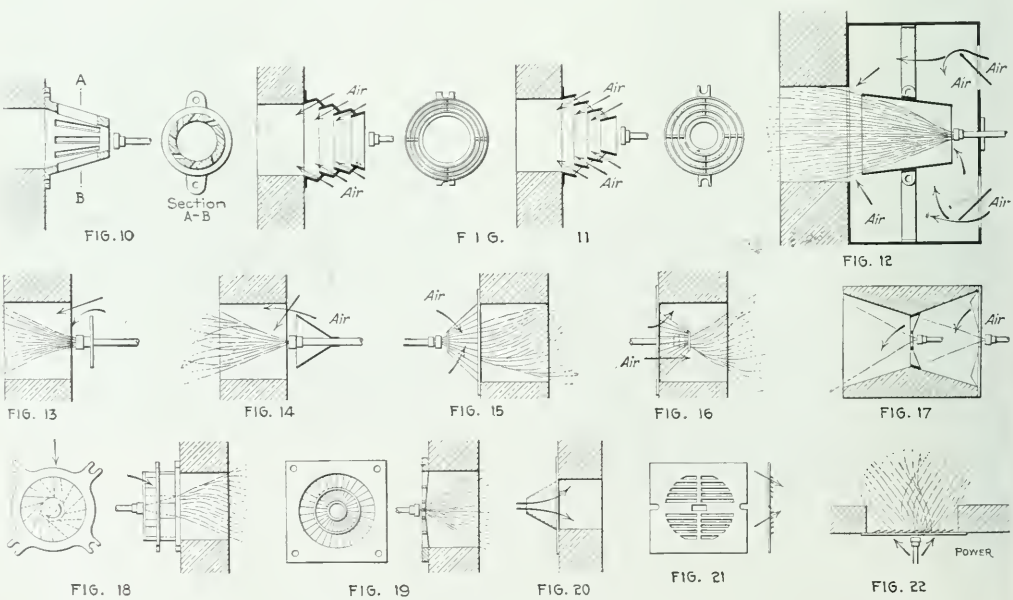


Fig. 10 Fig. 11 Fig. 12 Fig. 13 Fig. 14 Fig. 15 Fig. 16 Fig. 17 Fig. 18 Fig. 19 Fig. 20 Fig. 21 Fig. 22

*First part of this paper, which was read before the Society of Naval Architects and Marine Engineers, appeared in Power, Feb. 11, 1913.

room side of the burner tip to produce the effect of directing the air to the oil spray. The plate was tried in various positions and removed entirely, but no whirling motion was obtained. Fig. 14 is a sheet-iron cone placed

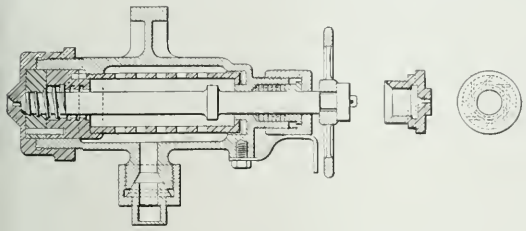


Fig. 23. Thornycroft Burner

over the burner tip to direct the air. The cone was tried in various combinations with regard to the burner tip and opening to the furnace without obtaining a whirling motion. Fig. 15 represents a conical-bladed air impeller by which the air was given a whirling motion and directed in toward the axis.

Fig. 16 is the reverse of the last figure. The air is given a whirling motion but directed away from the axis. Fig. 17 is a venturi tube effect. The air is given a whirling motion by means of a flat-bladed air impeller. A large impeller was set at the large diameter at the en-

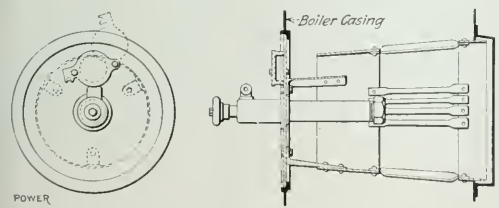


Fig. 23. Thornycroft Burner

trance of the tube, and in another experiment a small impeller was set at the contracted diameter of the tube.

A device for giving the air a whirling motion by delivering it in a plane at right angles to the axis of the burner, tangentially to an air chamber surrounding the burner tip is shown in Fig. 18. Fig. 19 is an impeller giving the air a double twist, the outer blades driving it one way and the inner blades driving it the other.

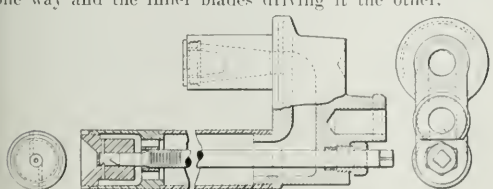


Fig. 26. Schutte-Koerting Burner

Fig. 20 shows a long horizontal slot admitting the air into a chamber enlarging toward the furnace. This device was used in connection with the flat-spray atomizer. Fig. 21 shows a series of horizontal blades located on a flat plate over an area of circular form, the blades below the center driving the air upward and the blades above the center driving the air downward. This was used with a flat-spray burner. Fig. 22 shows a series of vertical blades on a flat plate of oblong shape. The blades below

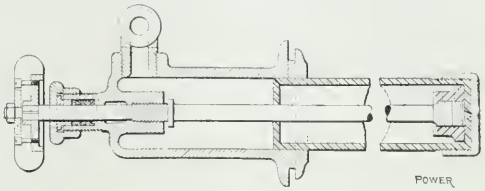


Fig. 24. Normand System

the center drive the air to the left and the blades above the center drive the air to the right. This arrangement was used with a flat-spray burner.

Principal Systems Used

In the following are briefly described the principal systems which have been installed in torpedo-boat destroyers.

Thornycroft, Fig. 23. In this burner the oil receives a whirling motion by passing through a spiral groove into a central chamber communicating with the outlet orifice of the tip. The tip fits on to a nozzle in which there is a cylindrical hole about the same diameter as the central chamber, and concentric with the axis of the burner. In the surface of this cylindrical hole a thread of square section is cut, of very slight depth at the end coinciding with the central chamber in the tip, but increasing rapidly in depth toward the direction of the opposite end of the burner at which the oil is admitted. A spindle fits into the cylindrical hole of the nozzle and on this spindle there is a corresponding thread, accurately fitting the thread of the nozzle and tapering to practically nothing at the end. When the spindle is screwed home the thread on the spindle bottoms on the tapered thread of the nozzle and no oil can get to the tip. As the spindle begins to be unscrewed, however, the marked taper of the two threads causes them to separate and form in combination a spiral groove, the sectional area of which rapidly increases as the spindle continues to be unscrewed. The central chamber is formed by the combination of the end of the spindle and the burner tip. The output of this burner is

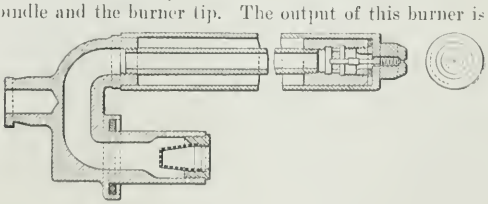


Fig. 27. Fore River Burner

controlled by the revolution of the spindle which regulates the area of the spiral oil passage.

The air for combustion is admitted through annular openings formed between concentric rings or short cylinders strung together to form a sort of truncated cone,

somewhat similar to the device shown in Figs. 18 and 19, except that in the present case the air is not directed toward the center.

Normand, Fig. 24. Eight small ducts deliver the oil tangentially to the central chamber formed by the combination of the tip and an adjustable spindle. The chamber is recessed so that the movement of the spindle does not in any way close or affect the ducts, its office being, besides forming one wall of the chamber, to close or throttle the outlet orifice. In the burner the ducts and outlet passage and orifice are made in a single piece which is held to the pipe or body of the burner by a clamp. The air-distributing device or tuyere consists of a truncated cone of sheet iron fitted on a portion of its surface with blades for giving the air a whirling motion, as shown in Fig. 25, on the preceding page.

Schutte-Koerting, Fig. 26. The tip of this burner is chambered out to receive a small spindle, less in diameter than the chamber except at the end, which is provided with a triple parallel thread which just fits the chamber and forms the oil to a smaller chamber at the end of the spindle communicating with the outlet orifice. The spindle is not adjustable, the burner capacity being varied entirely by controlling the oil pressure and temperature. This burner is fitted with a yoke and hand screw which holds it in position and provides a ready means for disconnecting. The air distributor is a truncated cone provided with longitudinal slots or openings which may be varied in area by means of a cover or register revolving on the outside and regulated by suitable mechanism. The air does not receive a whirling motion, the mixture with the oil spray being obtained by carrying a high air pressure and forcing it through the restricted area of the slots at high velocity.

Fore River, Fig. 27. An adjustable spindle in this burner is arranged to throttle or close the outlet orifice and to vary the size of the central chamber to which the oil is delivered through two tangential ducts, and the burner is provided with a quick detachable arrangement for holding in place.

The air distributor is a cone provided with air slots in the side which give the air a whirling motion, the area of these slots being controlled by regulating mechanism. The angle of the cone is about 60 deg., which is much greater than that of any of the designs above described, and another difference lies in the fact that all the air enters through the slots and none around the burner. The slots, besides being so arranged as to give the air a whirling motion, are greater in area in the direction of the furnace.

Summary

In the preceding pages the author tried to show that while the problem of oil burning presents some difficulties, particularly as regards admission of air, there is no mystery about the matter. A strong leaning toward simplicity, "horse sense," and some experience, are a combination reasonably sure of giving good results. On the other hand oil is not water, and the manufacturers of water sprinklers who have recently, under the stimulus of the times, entered the field of oil burning and steam generation, will find something more required than a table of steam properties and a few analyses of oil, and will certainly learn the fallacy of the theory that "It's all in the nozzle"

The Ferranti Steam Gas Turbine

For some years it has been known that Dr. S. Z. de Ferranti, past president of the Institution of Electrical Engineers, has been engaged in experimental work in connection with the steam turbine, with a view to the utilization of steam in the condition of an approximately perfect gas; that is, superheated far above its saturation point; but the details of his engine, and the degree of success that he had attained, were kept strictly secret. Now, however, in the course of the annual lecture in honor of James Watt, which he recently delivered at Greenock, Dr. Ferranti has taken the world into his confidence.

In the course of his lecture, he pointed out that there was a natural division between the steam turbine and the internal-combustion engine, the former being at its best when built for large powers, while the latter was most suitable for small powers, and referring to the strenuous efforts which are being made, especially in Germany, to develop the Diesel engine in large sizes for marine propulsion, he stated that few people had any conception of the failures and breakdowns which had repeatedly occurred with the big experimental engines that had been constructed, as these facts were carefully concealed from the foreigner. Turning to the steam turbine, he said that the economy increased as the temperature was raised, but mechanical difficulties were met with at high temperatures; however, he had commenced experimenting some years ago with a view to overcoming those difficulties and had now succeeded, after expending much time and money, in producing a turbine which was quite free from such troubles even at the highest temperatures, and under wide and rapid variations of temperature. Dr. Ferranti stated that in spite of the high temperature, his turbine runs with certainty with an extremely small clearance over the blades, diminishing leakage to a negligible quantity, and without any risk of stripping.

Not only is the steam superheated before admission to the turbine, but it is also resuperheated after the first expansion, and when exhausted from the turbine it is still in a superheated condition—whence the designation "steam-gas" which is applied to it. Before the steam enters the condenser it passes through a heater, by means of which a large portion of the heat energy is recovered. The blades are of mild steel, faced with a thin coating of pure sheet nickel electrically welded on, and are most accurately finished to shape by a process of step-by-step pressing, under very heavy pressure. The whole of the blading is electrically welded in position by automatic machinery so as to avoid straining, due to calking, which occurs at the high temperatures employed, and to prevent loosening, due to the same cause. Although the turbine is of the reaction type, a balance dummy is not employed, the end thrust being taken on a specially constructed thrust bearing, which prevents steam leakage.

A turbine built on these lines, of 5000 hp., has been running for some time, driving a large plant. When tested at two-thirds load, it is claimed to have produced a shaft horsepower on a consumption of 7 lb. of steam per hour, which is, of course, far in advance of anything previously attained. This could be supplied by an oil-fired boiler and superheated steam with a consumption of 0.625 lb. of oil per hp.-hr. As the turbine is constantly running on a variable load, it is difficult to ob-

tain an opportunity to carry out the full-load tests. Dr. Ferranti anticipates that when applied on a large scale, the system will be capable of attaining an overall thermal efficiency of 29 per cent. at a steam consumption of less than 6 lb. per hp.-hr.

It will be seen that in this turbine the Diesel oil engine has a formidable competitor in point of fuel consumption, as well as capital cost, which at present heavily handicaps the Diesel type. The large size of the experimental turbine also gives confidence in the results, which would have been lacking if only a small machine had been built.

Diehl Electrically Controlled Draft Regulation

A system of electrically controlled draft regulation has been evolved by the Diehl Manufacturing Co., Elizabethport, N. J. An electric motor in combination with a blower is shown in Fig. 1. The motor drive tends to materially lower the initial cost, because a high-speed fan may be used. One of the principal features of the outfit is flexibility of speed control, as the draft must be automatically regulated to suit conditions, and it is changeable at will.

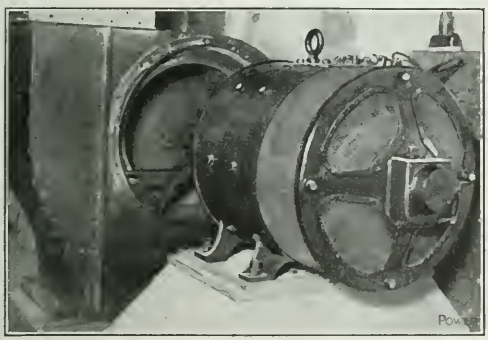


FIG. 1. MOTOR-DRIVEN FAN

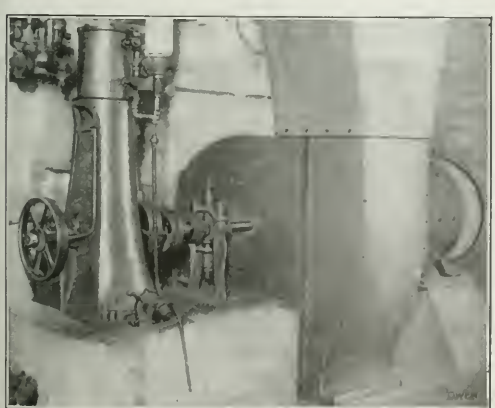


FIG. 2. MOTOR AND ENGINE-DRIVEN FAN

To provide against loss occasioned by a breakdown, duplicate motors can be arranged on either side of the fan, one only being coupled, and the spare motor ready to couple on at a moment's notice. This installation may be varied by the use of an electric motor and steam-engine relief unit, as illustrated in Fig. 2.

The motor is shunt wound and protected from dust and dirt. A steam-damper regulator is mounted alongside the electrical-control panel, as shown in Fig. 3. An automatic solenoid self-starter is shown below the steam gage; the change-over switch for either motor is shown alongside. Below are illustrated the chains, sprockets and counterweight which regulate the motor speed in accordance with the movement of the regulator attached to the wall.

The automatic action is as follows: Assuming that the steam pressure is high, the damper-regulator piston is at the extreme end of its upstroke, thus bringing the starting lever to the position shown, stopping the motor. As soon as the steam pressure drops, the regulator operates, transmitting its movement through the cord and chains to the two circular contacts shown under the rheostat.

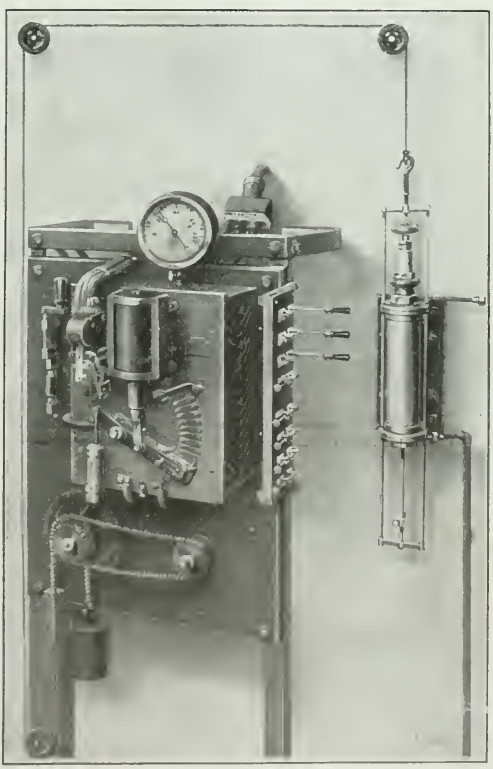


FIG. 3. DAMPER REGULATOR AND ELECTRICAL CONTROL

This movement closes the clapper switch and operates the automatic motor starter, giving the minimum speed available. The chains and sprockets transmit further movement of the damper regulator to the control arm of the motor field resistance attached behind the board

and not shown, the contact lever traveling over a series of 60 contacts, which movement increases the speed to any given point or maintains it at any one point, according to draft requirements. When the counterweight drops, the contact lever returns to the slow speed or "Full Off" position. A series of speed-limit switches is attached to the panel.

At times when the weather conditions are good and produce a strong natural draft, the motor is stopped an appreciable part of the time, resulting in a saving of power, but is ready to be instantly started when conditions alter.

Boiler Explosion at Pine Barren, Fla.

On Jan. 13, one of the two boilers in the plant of the McMillan Lumber Co., Pine Barren, Fla., exploded, killing the engineer and seriously injuring the fireman and three other persons.

The boilers were of the horizontal return-tubular type, connected to a common header and had only one pop-safety valve to serve both boilers. They were operated at 100 lb. pressure and supplied steam for a planing mill and dry kilns.

According to our correspondent, the explosion was due to low water; both boilers were fed with injectors only. The boilers had been in service about nine years. Some of the tubes were coated with scale and others showed evidence of pitting.

The boiler that exploded, burst at the crown-sheet, tearing the plate for nearly half the circumference of the shell. The boiler seems to have been given a rolling motion around its longitudinal axis when it exploded, as circumstances indicated that the dome of this boiler struck the other with such force as to move it about 30 ft. from its setting.

Both heads were severed from the shell and seventeen of the sixty-four tubes remained in the heads. There was very little shearing of the rivets, the plates tearing away at the joints.

The engineer, who was in the boiler room at the time of the explosion, was found covered with débris; he died an hour later. The fireman was found pinned under the smoke-stack.

St. Louis Engineers Incitation Club

On Jan. 25, at the Nord-West Turn and Liederkranz Hall, the Engineers Incitation Club, composed of St. Louis stationary engineers, gave a very successful masquerade and theatrical ball. The proceeds will be used to prepare information for those interested in the work of the isolated plant.

The proposition is a vital one at the present time, says the St. Louis "Star," because of the nearing to completion of the Keokuk dam, which is to generate the power transmitted to St. Louis to supply factories and other places where electricity is used. The central station electric power plants have been making inroads on the privately owned or isolated steam and power plants, in the office and commercial buildings in St. Louis.

Many of the isolated plants have been closed, and current for power and light has been contracted for from central stations. The entrance of current from the Keokuk dam is expected to further encroach upon the work of the isolated or privately operated light, heat and power plant.

Members of the Engineers' Incitation Club combat the contentions of the public service corporations that they can furnish service and power cheaper than the commercial or office building plant, and it was to incite something better that the stationary engineers formed the club. During the last year the club completed several tests under varying conditions of service to arrive at the cost of isolated plant service with competent engineers and service rendered by central stations.

The Incitation Club claims that the isolated plant in the hands of a competent engineer can be operated more economically, give better service and always have help at hand for any incidental mechanical service. Current from central-station plants for light or power is one charge; heat and hot water service is a second and extra charge, and any maintenance or extra mechanical work must be done by outside high-priced mechanics. That engineers may ascertain the exact cost of the light, heat and power as well as the service rendered, the club has prepared a record book, covering the year 1913, which will enable the engineer to keep a record of the service rendered by the plant, as wall as the cost of every item entering into the production of the light, heat or power. These books were given to the men who attended the ball and free copies may be had of the members.

Electrical Baths for Edison Employees

Electrical baths will be one of the features of the new clubhouse of the Association of Employees of the New York Edison Co., which opened Feb. 4, at 113 East Twelfth St., New York City. All of the 3000 members of the association may now avail themselves of the benefits of electric bathing, along with the other privileges which the new clubhouse offers, such as bowling alleys, a music room, pool and billiard rooms, and a library of 1800 volumes.

William T. Dempsey, who has charge of all of New York City's electric street lighting, is president of the association, which has as its chief objects, welfare and educational work. Its members may avail themselves of a four-year course of instruction in electrical engineering under competent teachers without any cost to themselves, a thoroughly equipped laboratory being maintained for this purpose. Owing to its complete and unusual electrical equipment, this new clubhouse might almost be called the electrical clubhouse.

SOCIETY NOTES

The fourth concert, banquet and dance of the combined associations of the N. A. S. E., of Philadelphia, Penn., was held at Lulu Temple, Thursday evening, Jan. 30. The combination comprised Quaker City No. 1, Tacoma No. 9, Merrick No. 12 and Northeast No. 20.

There were upward of six hundred persons present, among them being many prominent engineers and representatives of supply houses. From 7:30 to 8 o'clock there was an organ recital followed by an entertaining vaudeville performance, at the conclusion of which the company adjourned to the banquet hall, where an appetizing dinner was served. Dancing concluded the evening's enjoyment.

A lecture and demonstration on smoke-recording, flue-gas analyzing and soot cleaning was given on Thursday evening, Jan. 16, at Masonic Temple Building, under the auspices of the Decatur Association, N. A. S. E., at Decatur, Ill. F. A. Moreland, of the G. L. Simmons Co., Chicago, assisted by Anson Gale, delivered the lecture.

PERSONALS

Richard S. Buck has retired from the firm of Sanderson & Porter to accept the position of chief engineer of the Dominion Bridge Co., Canada. Seton Porter has been made a partner in the first-named company.

E. T. Adams, former manager and chief engineer of the gas and mill engine department of the Allis-Chalmers Co., Milwaukee, Wis., and recently president of the Wisconsin Engine Co., Milwaukee, has been appointed chief engineer of the Rumeley Co., La Porte, Ind.

Where mine power plants are located near or over the mine itself an easy and economical method of disposing of the ash is to arrange a tunnel under the fire boxes, with a slope of not less than ⅜ in. to the foot. Connect this with a bore-hole and wash the ashes down the latter, with mine water, where they may be used for flushing abandoned workings if desired.—"Coal Age."

POWER

Vol. 37 NEW YORK, FEBRUARY 25, 1913 No. 8

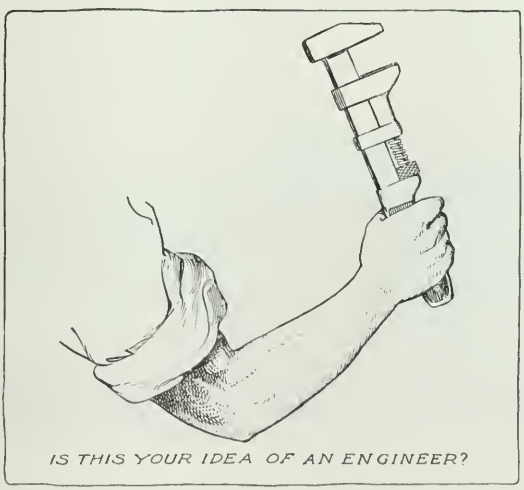
Hank Armstrong, Engineer(?)

By R. T. Strohm

They built a sawmill, some years back,
Acrost the way from Hackensack;
An' when they sought an engineer,
Hank Armstrong thought he'd volunteer.
Sez he, "I've ran a mow'n machine
An' grindstone sence I was thirteen,
An' sulky plow an' corn drill, too."
They said they kinder guessed he'd do.

He filled that b'iler full's a tick
With water hauled from Slocum's Creek;
An' then he took that firebox
An' chucked it full of hemlock blocks.
He throwed in coal oil by the cup,
An' lit a match to start 'er up.
The flame shot out as he looked in
An' singed the whiskers off his chin.

That thingumbob that stands on top
Jumped open with an orful pop,
An' steam come shootin' in a cloud
Till Hank he said he kinder 'lowed
The thing was makin' such a noise
That it might rile the other boys.
An' so he twisted down the nut
Ontil the pesky thing stayed shut.



IS THIS YOUR IDEA OF AN ENGINEER?

We never thought Hank knowed so much
'Bout b'ilers, injines, belts an' such.
Why, if a bearin' box got hot,
He'd just splash water on the spot
Ontil the place got cool, an' then
He'd start the whole shebang again.
Or if a belt got slack an' slipped,
He'd smear on tar ontil she gripped.

Hank said he never worked by rule,
'Cause any sort of goldarned fool
Could use horse sense an' mend a piece
With monkey-wrench an' elbow grease.
Onct when the guvner shaft got bent,
He grabbed his monkey-wrench an' went
An' hit the dingus one good smack
Acrost the side an' bent it back.

An' regular, twelve times a week,
The b'iler jints 'ud spring a leak.
Then Hank 'nd jump up off his bench
An' grab that doggone monkey-wrench,
An' go an' hammer every seam
Till it would quit its spittin' steam.
An' when we ast him, "Won't it bust?"
Hank grinned an' said, "In God we trust."

Deerfield River Hydro-Electric Development

By Warren O. Rogers

SYNOPSIS—A five-million-dollar hydro-electric development of New England. The generating stations, storage reservoirs, dams and tunnels are described.

When Jonathan Catlin and James Ryder settled in what is now Shelburne Falls, Mass., some time between 1752 and 1756, and while treacherous Indians were roaming the forests and paddling their canoes upon the waters of what is now known as the Deerfield River, hydro-electric developments were unknown and undreamed of. The first water power of the town is said to have been developed by three men, David Fisk, Squire Barnard and an unknown, who operated a small grist and sawmill. This mill was doubtless located below the natural fall for which the town is named. The falls are of natural rock formation, as indicated by Fig. 1, which is a view of them as they appear at present.

Although the waters of the Deerfield River have turned the wheels of many industries, the development was along similar lines until a small hydro-electric station and dam was put in by the Greenfield Electric Light & Power Co. in 1904, at a point about one mile south of Shelburne Falls. The dam at this development is of modern concrete construction and the water is conveyed to the power house through a canal. The plant has a capacity of 1300 hp., and is operated in connection with the steam plant of the company at Greenfield, Mass.

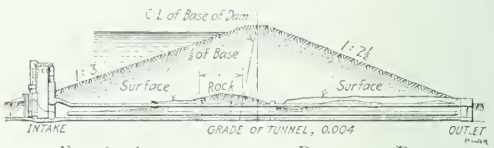


Fig. 2. Section through Reservoir Dam

However, the most interesting development from economic, hydraulic and electrical standpoints on the Deerfield River is that which has practically reached completion at or near Shelburne Falls. The company responsible for this work is the New England Power Co. The general contract for all of the work on the river is held by the Power Construction Co., whose headquarters are at Shelburne Falls. This company has done the engineering work for all the work on the river and has built with its own forces the storage dam and reservoir in the upper valley and all but one of the transmission lines. The four power plants have been built by subcontractors under the supervision and direction of the Power Construction Co.

At present there are four developments on the river: three near Shelburne Falls, and the other about three miles north of Hoosac Tunnel, Mass., the railroad station on the Boston & Maine R.R. near the east entrance of the tunnel.

If one were to view the Deerfield River in July or August, the conclusion would be reached that it was a most undesirable stream for hydro-power-plant development, as the water supply would appear altogether insufficient to make such a proposition a paying investment. This river is the principal tributary of the Connecticut River and rises in the southwestern part of Vermont. If a map of Vermont and Massachusetts were examined it would be seen that the river has no particular source, but is formed by a number of small streams which drain a large area of southern Vermont, about 250 square miles. The only outlet of the river is through a narrow valley which runs south. The Deerfield River proper rises in the town of Stratton, Vt., and flows south, increasing in volume at East Branch Brook at Searsburg. This brook rises in the town of Somerset, Vt., and near its head waters at Peck's mill the first reservoir is being built. At Wilmington, Vt., the river is again augmented by the waters of the North Branch, and thence winds its way southwest until it crosses the Massachusetts boundary line; it then flows south through a narrow valley.

Fig. 1. New Dam at Shelburne Falls, Mass.

Fig. 3. Power House, Dam and Sluice Gates, No. 2 Development

The hills on either side have an elevation of from 800 to 2000 ft. above the sea level. In this narrow valley at a point midway between Munroe Bridge and Hoosac Tunnel, No. 5 development is being constructed. At the east side of the Hoosac Mountain the river runs southeast through a mountainous valley until it nears Charlemont, where the valley broadens out and the turbulent water

thence flows placidly to within two miles of Shelburne Falls, where the river again flows through a narrow valley. At this point the river makes a sharp turn around a hill about 600 ft. above the sea level and flows north through a deep ravine and then bends to the east and again to the south, receiving at this latter bend the water of the North River, which also rises in Vermont and drains an area of about 100 square miles, making a total watershed of approximately 520 square miles. It is at this horseshoe bend in the river that No. 4 development has been built. From the mouth of the North River the flow is almost due south through Shelburne

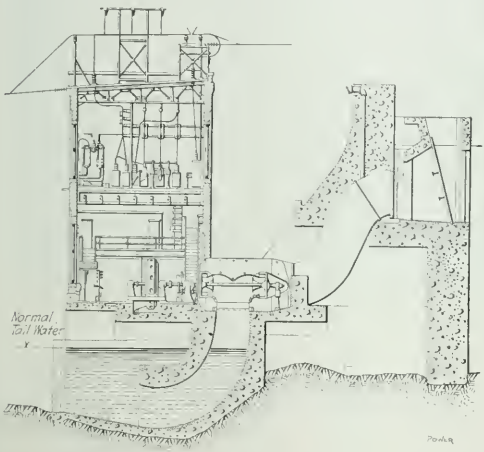


Fig. 4. Cross-section through No. 2 Plant

Falls, where the river makes an abrupt plunge over the falls to which reference has already been made.

From the falls the river flows southeast, the valley continues to be steep for about 10 miles, through which section a large number of power plants may be built as

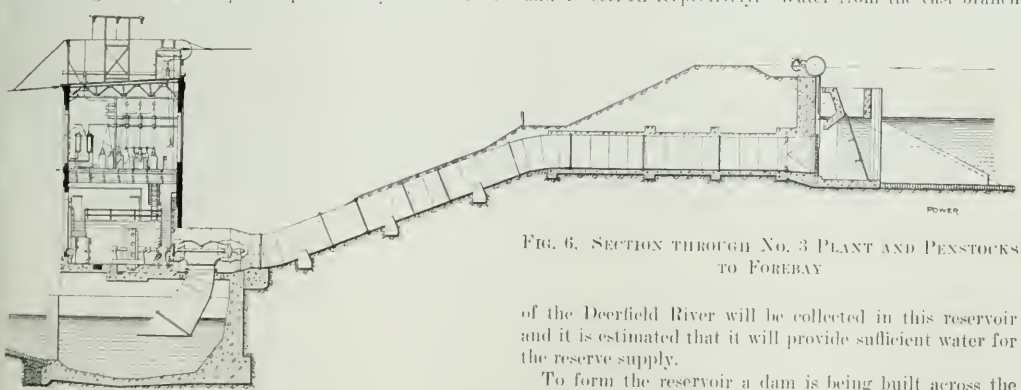


Fig. 6. Section through No. 3 Plant and Penstocks to Forebay

closely as the back water level of each will permit. It is in this section that Nos. 2 and 3 plants have been built and where No. 1, not yet begun, will be situated.

Although the flow of water during the dry summer months would not be sufficient to provide a maximum supply for the power plants, the deficiency is taken care of by the Somerset reservoir.

Somerset Reservoir

During the winter and spring the Deerfield River is frequently changed from the inconsequential appearing stream of the summer to a roaring, raging torrent. This

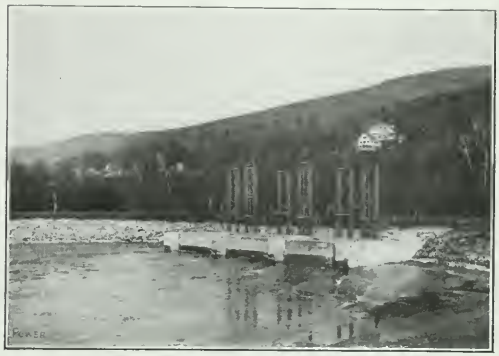


Fig. 5. Forebay of No. 3 Power Plant

water would flow over the dams without doing work if no provision were made to store it for use during the time that the supply of water from the drainage area was not sufficient to carry the maximum load of the power plants.

Therefore, the Power Construction Co. is building an immense storage reservoir at Somerset, Vt., near the source of the water supply, in which to store the surplus water in the winter and spring to be released during the time of low water. It will be seen how necessary this provision is, when it is understood that the monthly average discharge of water at Shelburne Falls ranges from 380 sec.-ft. to 2000 sec.-ft. in an average year and maximum and minimum flows have possibly reached 50,000 and 20 sec.-ft. respectively. Water from the east branch of the Deerfield River will be collected in this reservoir and it is estimated that it will provide sufficient water for the reserve supply.

To form the reservoir a dam is being built across the east branch of the Deerfield River. It will be 2110 ft. long, and 110 ft. high at the highest point. The base will be 600 ft. wide at the maximum section and the flat top 20 ft. wide. The down-stream side of the dam will have a slope of 2.5 to 1, the up-stream being 3 to 1. The dam will be riprapped on both slopes. The reservoir

will have an area of about three square miles and will have an available storage capacity of approximately 2,500,000,000 cu.ft. with the water at the level of the spillway. The use of low flashboards on the spillway will increase the capacity of the reservoir by about 300,000,000 cu.ft.

The sluiceway and gates controlling the amount of water to be let down the stream during the dry season, will be near the east end of the dam. The discharge tunnel is 521 ft. long, in a trench cut in solid rock, concrete-lined and made in the shape of an inverted horseshoe, 11½ ft. high and 12 ft. wide. It will carry two 4-ft. delivery pipes through which the water will be discharged from the reservoir. In Fig. 2 is shown a cross-section of the earth dam.

A second storage reservoir, of about 4,500,000,000 cu.ft. capacity, will be built near the Massachusetts boundary line in Vermont and will be operated in series with the Somerset reservoir.

The Somerset dam will have a spillway about 200 ft. long, cut in the rock, and will provide an outlet for the reservoir in times of high water. It will be some time before this system of reservoirs will be in operation. Although the reservoirs and source of water supply are north of the power stations, the developments are numbered up stream. Thus, No. 1 power house and dam has not been commenced, while a few miles up the river from its probable site, No. 2 plant and dam is practically completed. A view of this work is shown in Fig. 3. Inasmuch as all of the generating stations are designed practically along the same lines, a later description of No. 4 development will answer for all three developments now completed. No. 5 plant is not completed and will contain differently designed generators.

No. 2 Development

This installation is about three miles below Shelburne Falls. The power house is built below the west end of the dam and very close to it. Water will be delivered to the three waterwheels through three 11-ft. steel penstocks. The dam has a maximum height of 90 ft., is 450 ft. long and has a spillway 276 ft. long. The base of the dam is 75 ft. thick and the top 10 ft. 6 in. wide. The spillway is of an ogee shape and extends from the headworks back of the power house, which headworks are 16 ft. higher than the dam proper to the east side of the river.

Short penstocks, connecting from the up-stream side of the dam with the waterwheels, have screens and gates. The dam has sluice gates, shown in Fig. 3, which facilitate the discharge of water. As shown, this station is at

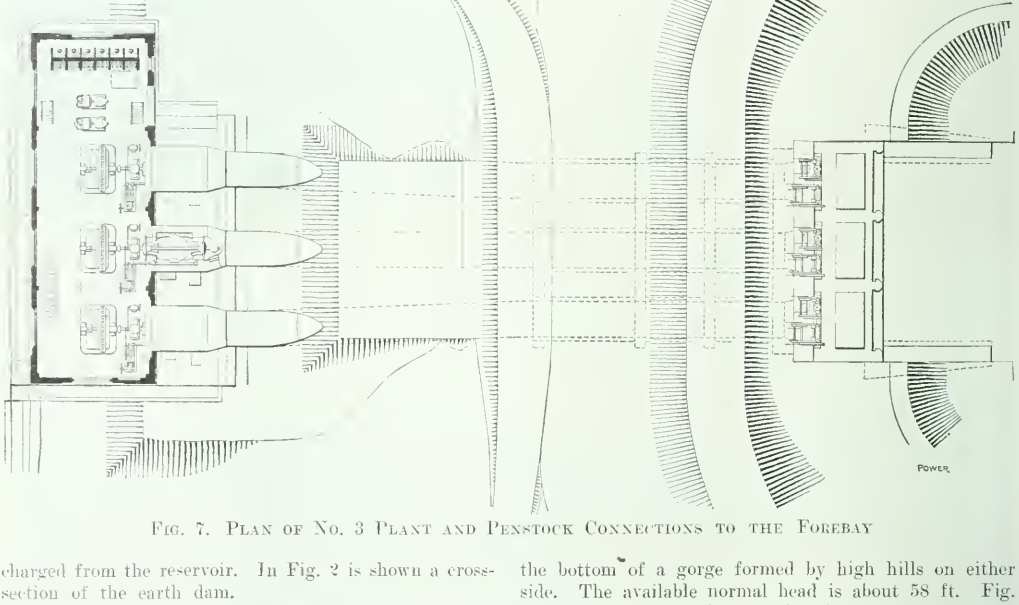


Fig. 7. Plan of No. 3 Plant and Penstock Connections to the Forebay

the bottom of a gorge formed by high hills on either side. The available normal head is about 58 ft. Fig. 4 is a cross-section through the plant and dam.

No. 3 Development

Station No. 3 is a short distance below the dam shown in Fig. 1. It is supplied with water from the storage supply above the dam by a conduit, canal and penstock. The new concrete dam has been built just downstream from the old timber crib dam, and is now 475 ft. long and 15 ft. high in maximum section. The intake delivers water to a reinforced-concrete conduit 12 ft. 6 in. by 17 ft. and 600 ft. long, which runs under a manufacturing establishment at the west end of the dam. The discharge is into a canal 920 ft. long, which terminates in a forebay, a part of which is shown in Fig. 5. The gates and concrete headworks are also shown. The gates control the water supplies to the three waterwheels through three 10-ft. penstocks, as shown in Fig. 6, which also shows a section through the plant. The Penstocks are each 160 ft. long and deliver water to the waterwheels at a normal head of about 64 ft. A plan view of the entire plant, penstocks and part of the forebay is shown in Fig. 7.

A view of No. 3 station from the top of the forebay is given in Fig. 8. Unlike Nos. 2 and 4, it is but one

story high for a part of its length and two stories for the remainder. The second story contains the oil switches, storage batteries and transformers. It will be noticed from Figs. 4, 6 and 8 that the casings of the water-wheels are placed outside of the buidlings; the same conditions obtain at plants Nos. 2 and 4.

No. 4 Plant

This installation is about 1¼ miles above Shelburne Falls. The power house is on the west side of the river and at the foot of a high hill. Owing to the topographical conditions at this point the dam was built on the other side of the hill around which the river winds. The dam is 240 ft. long at the crest and is built at an angle with the river to obtain a greater spillway to take care of high water in times of freshets. It is anchored on solid rock bed, and is 44 ft. high in maximum section and 10 ft. 6 in. wide at the top. At one end of the dam are three surface sluices, each 10 ft. wide, while at the other end is a submerged sluice 6x8 ft. controlled by a heavy cast-iron gate.

Although the river flows north, east and south in getting past the hill under which the power house is located, the tunnel from the dam intake to the forebay is made in a straight line and is 1518 ft. long, the power house being directly opposite the first bend in the river, but on the opposite side of the hill.

Like those at the other stations, each penstock has two gates, each 7x12 ft. in size. Fig. 9 gives a view of the forebay and head gates. The power house is shown beyond, and below the level of the forebay. This building differs from the No. 3 building, in that it is two stories high throughout, and the switches and transformers occupy the entire upper floor.

This station is perhaps the most interesting on account of the tunnel work. The concrete-lined tunnel is in the form of a horseshoe and has an area equal to a circle 13 ft. in diameter. It is built with its highest point in the middle to facilitate drainage during construction. The tunnel extends from just above the dam to the forebay on the east side of the hill, the tunnel intake is controlled by a steel gate weighing about 34,000 lb., operated by a 15-hp. motor. The three penstocks are each 10 ft. in diameter and of riveted steel, varying in thickness from ¼ in. at the top ends to $\frac{5}{16}$ in. at the bottom. The turbines discharge through draft tubes into a tailrace which discharges directly into the river, as shown in Figs. 4 and 6.

Work on the tunnel was started in December, 1911, and five months later the hole through the hill was made. The amount of rock excavated is estimated to have been 12,000 cu.ft. With the exception of about 120 ft., the bore is through solid granite. In Figs. 10 and 11 is shown the concrete work at the inlet and outlet of the tunnel. Some idea of the amount of work necessary to make the forebay can be gathered from Fig. 12. The forebay is about 200x225 ft. at the top and 50x75 ft. at the bottom, and is 33 ft. deep. The basin is of earth with riprap lining, and will impound approximately 2,000,000 gal. of water.

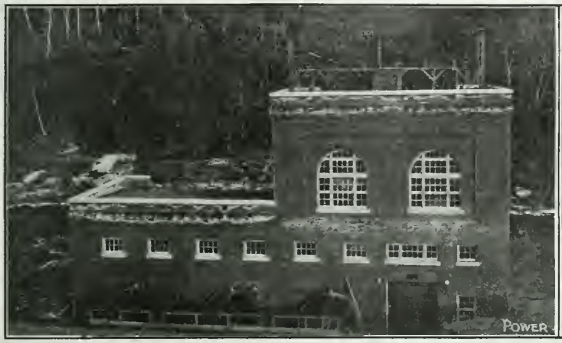


Fig. 8. Penstocks of No. 3 Power Plant

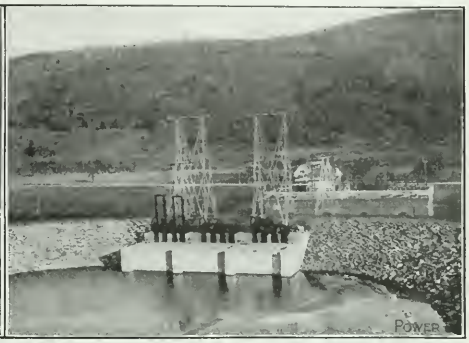


Fig. 9. Forebay of No. 4 Development

Fig. 10. Tunnel Intake Practically Completed

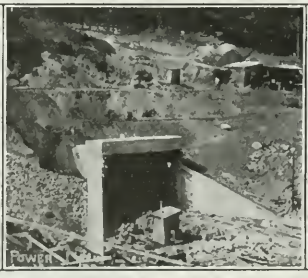


Fig. 11. Tunnel Outlet Concrete Work

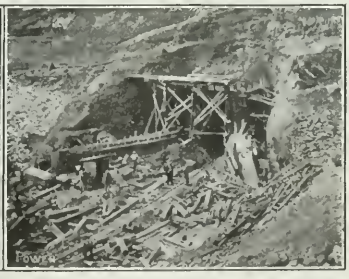


Fig. 12. Tunnel Outlet for Forebay Under Construction

Equipment of Power Plants

As already stated the equipment of the three stations is practically identical, both hydraulically and electrically. Each of the three stations at Shelburne Falls contains three 2000-kv.-a., 2300-volt, three-phase, 60-cycle General Electric generators, each directly connected by a horizontal shaft to a 3200-hp. double runner, central discharge Wellman-Seaver-Morgan turbine, running at 257 r.p.m. The speed of each unit is governed by a Lombard special horizontal governor, directly connected to the turbine-gate shaft, and belt-driven from the generator shaft. All governors have a 30,000-ft.-lb. rating. The governors operate under oil pressure supplied by a 4x6-in. triplex, plunger pump. The generators are installed along one side of the generator room, as shown in Fig. 13. The governors are placed between the generators and the inside end of the turbine casing, which extends slightly into the generating room. Fig. 14 shows this feature.

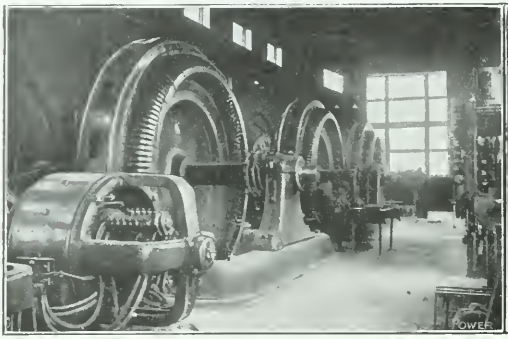


Fig. 13. Generator Room

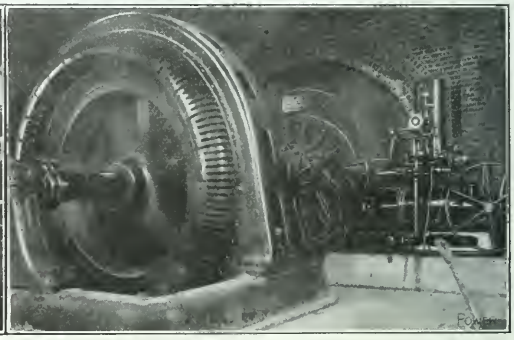


Fig. 14. Special Design of Governor

Each plant has two exciter units, but none is driven by an individual waterwheel. Each unit consists of a 150-hp., 2300-volt induction motor driving a General Electric 100-kw., 125-volt generator. The reason for depending upon motor-driven exciters is because each station is tied to the others and also to the Vernon, Vt., power plant, described in the Sept. 28, 1909, issue of Power. There will doubtless never be a time when electrical energy will not be available to operate the induction motors.

Transformers and Oil Switches

There are three 300-kv.-amp. water-cooled, oil-insulated transformers in each station, transforming from 2300 to 69,000 volts, placed on the second floor of the station. The oil switches, of the remote control type, have a rating of 150 amp. per terminal at 70,000 volts, and are connected overhead through the 69,000-volt buses to the transformers, occupying the second floor.

All the transformers rest upon rails leading to an opening in the floor at one side and midway of the building, which permit of lowering a transformer to the floor below by a 30-ton chain-block hoist, where it can be handled by a hand-operated traveling crane.

Cooling water for the transformers is supplied by direct connection to the penstocks. In an emergency the oil in the transformers can be discharged into the river through a 4-in. pipe, by operating a quick-opening valve. Fig. 15 shows a view of the transformers and oil switches.

On the opposite side of the generating room, midway of the building is a 10-panel operating switchboard. It controls the three generators, two exciter units, two 3000-kv.-a. transformers and the outgoing 66,000-volt lines of which there are two from No. 3 station and four from Nos. 2 and 4. Each station has a storage-battery system for controlling the oil switches.

Transmission Lines

In Figs. 6, 8 and 9 may be seen how the high-tension wires are suspended on the station roof. All lines are dead-ended on strain insulators fastened to the station wall. From these taps are carried to insulators supported on a steel framework. The lines are spaced horizontally, about 8 ft. apart, and are carried 15 ft. above the roof.

All transmission lines now under construction comprise two three-phase circuits of Nos. 1 or 2/0 cable. One line runs from a junction point opposite No. 4 station to the Vernon station on the Connecticut River, a distance of 16 miles. Another double-circuit line of No. 1 copper cable extends 15 miles from the No. 4 station to No. 5 station, which will be described later. There is also a two-line double circuit extending from the junction point at No. 4 station down the river to No. 2 sta-

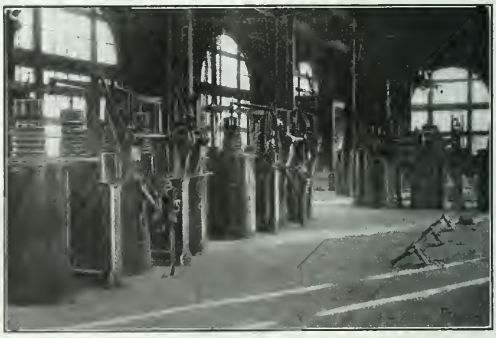


Fig. 15. Transformer and Oil Switches, No. 4 Plant

tion with a ½-mile tap to No. 3 station. From station No. 2 a double-circuit line of No. 00 cable extends 60 miles to Milbury, Mass., and a tie line runs from the latter point to the Greendale substation, 14 miles away, and a short distance outside of Worcester, Mass. There are also the double three-phase lines of the Connecticut Transmission Co., extending from Vernon, Vt., to Worcester, Mass., with several branches. Fig. 16 is a map showing the existing circuits in dark lines and the proposed circuits in dotted lines.

No. 5 Station

Development No. 5, which will operate in connection with the same series of power plants, is not completed. The station is a brick building, like the other power stations, and is about three miles from the Hoosac Tunnel station of the Boston & Maine R.R. It is reached by the Wilmington & Hoosac R.R. or by traveling over a winding road which follows the Deerfield River. The initial equipment of the station will include three 3000-kv.-a. transformers which will reduce the potential from 66,000

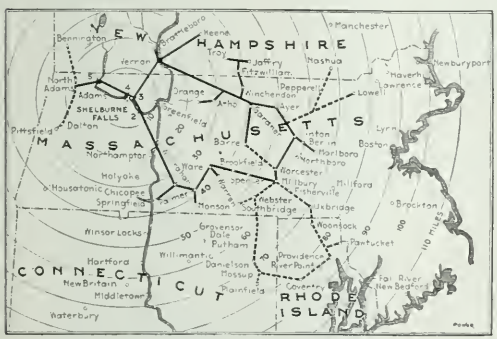


Fig. 16. Showing Existing and Proposed Electrical Circuits

volts to 2300, three 150-kw. exciter units, switching apparatus, lightning arresters and three frequency changers, each consisting of a 1250-kv.-a., three-phase, 60-cycle, 2300-volt generator directly connected to a 4000-kv.-a., three-phase, 25-cycle, 11,000-volt alternator or approximately 3000 kv.-a., single-phase. These 60-cycle generators will operate as synchronous motors to drive the 1100-volt generators which will supply power to operate the electric locomotives through the Hoosac Tunnel. These are at present operated from the Zylonite steam-power plant described in Power, July 4, 1911. When the waterwheel-driven generators are installed, of which there will be three, these two machines can be run as generators. This arrangement will also give a flexible interconnection between the systems and will permit of the Zylonite plant feeding back into the hydro-electric system in case of water shortage.

The waterwheels to be installed will be of 6000 hp. capacity and will be directly connected to the frequency changer sets above described, generating either single- or three-phase energy. The machines will be able to operate in parallel with those of the Zylonite plant in either single- or three-phase service. To meet the requirements of the heavy freight traffic through the Hoosac Tunnel the 25-cycle machine in each unit will be capable of developing 4300 kv.-a. for 20 min. of each hour at 70 per cent. power factor. During the remaining 40 min. of each hour the machine will be capable of operating at a load of 2000 kw.-a. at 90 per cent. power factor.

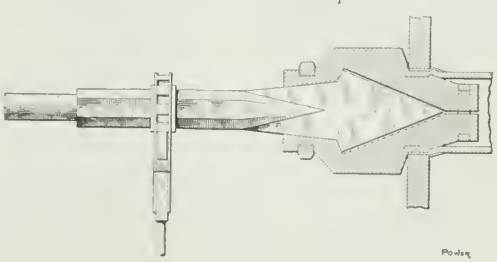
According to plans as now formulated the water to the turbines of No. 5 plant will come to them with a head of 200 ft. The dam will be about 2½ miles above the present station and the water will be conveyed to the top of the hill back of the power house through an alternate canal and concrete conduit, emptying into a forebay from which the water will come to the waterwheels through penstocks. Plans have also been formulated to some extent for another and larger plant, when the demand for electrical energy occasions its construction.

No. 5 power house is of brick and is 100x100 ft. and 60 ft. high. Large windows afford the admission of sufficient light. The concrete foundation extends 20 ft. below the water line and contains 3500 cu.yd. of concrete.

The developments above described will cost $5,000,000. The waters of this very erratic river have been made to produce electrical energy to be transmitted to distant cities and towns. In addition to the power generated by the stations of the New England Power Co., on the Deerfield River, there is a plan for additional water power controlled by the Connecticut River Co., to tie on to this system and form a combination capable of generating an ultimate capacity of 200,000 hp.

Moore Tube Expanding Beading Tool

Illustrated herewith is a section of a flue sheet and a flue and shim expander. The expander comprises two working members, held together by elastic bands at each end, forming an elliptical cylinder. A shoulder is formed for the enlargement inside the flue sheet. Lugs are provided to form the beading curve and between the lugs and the shoulder is the expander. The inner surfaces of the working members conform to the shape of the wedge which is struck with a hammer to expand the tube. A



Tube Expanding and Beading Tool

ratchet is provided for slowly rotating the device. The operations of placing, rolling and beading the tube are performed at the same time by the one tool.

It is handled by F. C. Worth, 310 Monadnock Block, Chicago, Ill.

Two cubic feet of water falling 6 ft. will produce 1 hp. of energy in the most modern electrical machinery. The total discharge of the Mississippi River into the Gulf of Mexico annually is 18,400,000,000,000 cu.ft.

Electrical Energy Meter

This device is designed to measure the energy of steam and gas engines. With it all the positive forces are added, the negative forces are subtracted therefrom and the net active forces measured. This is accomplished by applying the excess pressure of one side over that of the other side of the piston of the engine, to determine the voltage and direction of a current of electricity generated in a magneto by the varying motion of the piston in proportion to the pressure and motion, which determines the energy of the engine, and thus measures the energy developed by the engine.

In Fig. 1 is shown a longitudinal section of an engine cylinder and a top view of the magneto, also a front view of the meter forming a part of this device and details of other parts later referred to. Fig. 2 shows the device attached to a steam-engine cylinder.

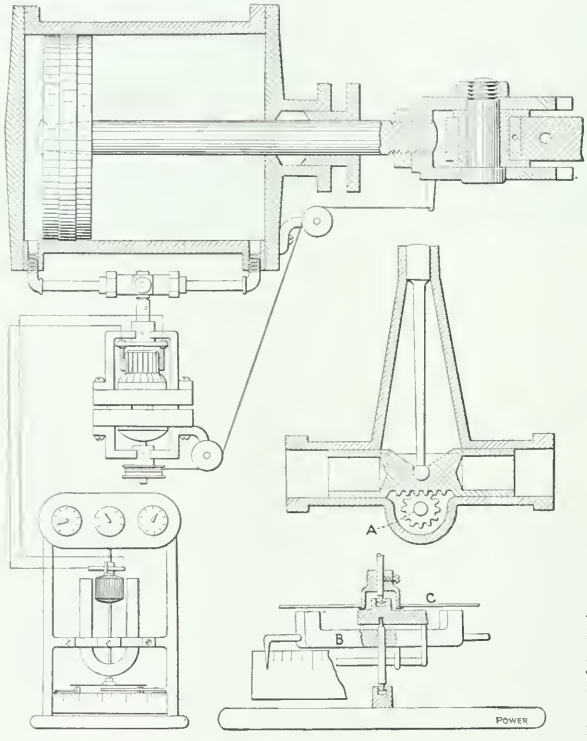


Fig. 1. Details of Meter and Connections

Referring to Fig. 1, a stud is rigidly fixed in the crosshead to which a cord is attached leading to a pulley on the shaft of the magneto.

To one side of the engine cylinder an auxiliary cylinder is mounted, an enlarged vertical section of which is shown in Fig. 1. The ends of the piston in this cylinder are put in communication with the corresponding ends of the engine cylinder by two tubes. The auxiliary cylinder has a casing forming a chamber, in the top of which a spring is rigidly secured with its lower end engaging in a socket in the piston. The chamber in the base of the cylinder contains a shaft carrying a pinion *A* that engages with a rack integral with the piston and operated by it.

The shaft projects from the end of the chamber and into a hollow shaft which forms a part of the magneto. Inside of the magneto pulley the outer end of a spiral spring is fastened; the other end is secured to one end of the bearing. The cord, by the movement of the engine piston, rotates the magneto pulley and armature in one direction, and the spring rotates the armature in the opposite direction to correspond with the reciprocatory motion of the engine piston and crosshead. While the armature is rotating in one direction, the pressure of the steam against the auxiliary piston forces it forward against the action of the spring an amount in proportion to the varying pressure in the cylinder, thus rotating the pinion *A* in, say a clock-wise direction. This motion is communicated to a movable brush-yoke on the magnet shifting the brushes away from the neutral point on the commutator in a clock-wise direction. As the voltage of the magneto at any given speed of the armature is proportional to the displacement of the brushes from the neutral points, and as the voltage of a magneto, for any given location of the brushes, is in proportion to the speed of its armature, the voltage at any instant will be in proportion to the combined effect of the location of the brushes with respect to the neutral points and the speed of the armature; these two conditions are governed by the varying steam pressure in the cylinder and the varying speed of the engine piston at the same instant. Therefore, the voltage will be in direct proportion to the pressure and motion which determine the horsepower of the engine.

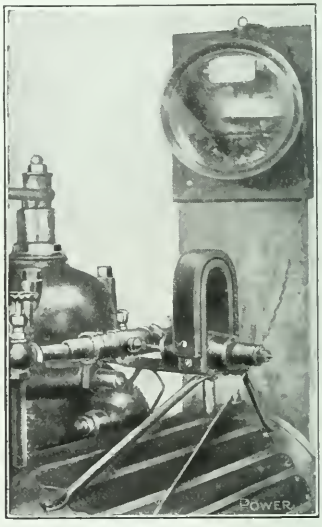


Fig. 2. Meter Attached to an Engine Cylinder

Having completed this stroke, the engine piston starts in the opposite direction and the pressure, introduced on the opposite side of the piston, is exerted against the opposite side of the auxiliary piston, moving it in the op-

posite direction, which motion is communicated to the brushes. The direction of the armature rotation also having been changed, the current from the magneto will be in the same direction as before.

Upon this return stroke, after cutoff, when the piston reaches the compression point, the compression pressure enters the auxiliary cylinder at the opposite end and reverses the piston, which moves the brushes to the opposite side of the neutral point before the direction of rotation of the armature is changed, and the current from the magneto will be in the opposite direction, having the effect of reversing the meter, which is wired in circuit with the magneto. Compression is taken into account because it does not represent active work, but is negative work and tends to retard the engine speed at the end of each stroke.

The meter, by which the horsepower-hours are registered and the horsepower is indicated, consists of any ordinary form of decimal wheels (not shown) and a dial plate which registers the total horsepower-hours. The meter is electrically connected to the magneto. The magnetic field against which the current delivered to the meter armature from the magneto acts, causes that armature to rotate in the direction in which the register adds when the current is in one direction, and in the direction in which the register subtracts when the current is in the opposite direction. The magneto furnishes current in one direction, when the pressure in the auxiliary cylinder is doing work, and the current will be in the opposite direction when the back pressure or compression in the engine cylinder is greater than the forward pressure. Therefore, the net result of all these conditions is that the meter will register the work done by the engine.

To directly indicate the horsepower of the engine there is a dial in the bottom of the meter and a magnet *B* secured to a lower shaft, as shown in the lower right-hand detail in Fig. 1. An index is secured to one end of *B* and indicates the horsepower developed by the engine on the dial. One end of a hair spring is secured to the magnet *B;* the other end is secured to the bottom pivot block. This tends to hold the magnet and the index in a zero position on the dial.

As the upper meter shaft is rotated from left to right, the forward direction of the meter, the magnetic torque, or pull, between the magnet *B* and the disk *C*, which is secured to the shaft, tends to rotate the magnet *B* in the same direction against the action of the hair spring and the deflection will be in proportion to the speed of the disk. This is in proportion to the power developed, and causes the index to indicate upon the dial the horsepower of the engine at any time.

This meter registers only the net or working horsepower of the engine after having subtracted all of the negative, exhaust or counter forces. The meter may be set in the office of the superintendent where it can be consulted at any time.

This energy meter is manufactured by the Loetscher-Ryan Manufacturing Co., Dubuque, Iowa.

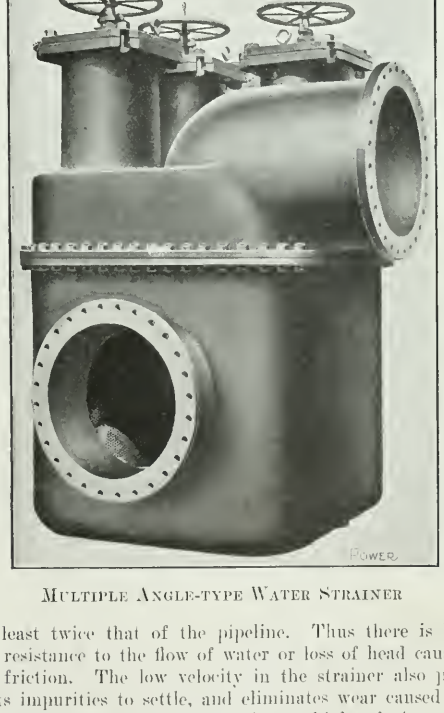
⁂

The smallest dynamo in the world is said to be the one now on exhibition in France, writes a New England engineer contributor. It is smaller than an American penny in diameter and weighs only one-fifth of an ounce, is 6 in. high, and used as a generator as well as a motor. It consumes 2 amp. at a pressure of 25 volts. The curious part of the whole thing is that it is accurately made, and can be operated by a small pocket battery.

Large Lagonda Multiple Angle Type Water Strainer

One of two large multiple water strainers recently built by the Lagonda Manufacturing Co., Springfield, Ohio, is shown in the accompanying illustrations. The Southern California Edison Co. will use the strainers to remove fish, sticks, leaves, seaweed, ice, etc., from the water supply to its power plant.

The strainers are not only of large size (30 in.) but are of the angle type, the water passing out in a direction 90 deg. from the inlet. Each strainer contains three filtering baskets, each having a free straining area equal to that of the pipeline. When one of the baskets is being cleaned, the two remaining baskets have an area



Multiple Angle-type Water Strainer

at least twice that of the pipeline. Thus there is little resistance to the flow of water or loss of head caused by friction. The low velocity in the strainer also permits impurities to settle, and eliminates wear caused by the erosive action of water moving at high velocity.

As the entire strainer can be set beneath the power-plant floor, only the handwheels and top of the bonnets project above. Any one of the individual baskets can be removed from the body of the strainer by turning one of the handwheels.

⁂

Extensions of the Niagara Falls Hydro-electric plants on the Canadian side are at present being pushed with the view of utilizing all the water available for power purposes under the existing treaty. The Toronto Power Co. will enlarge its output to 125,000 hp., and a new line, operating at 85,000 volts, is being built between Niagara Falls and Toronto. The plants on the American side of the Falls are at present using all the water allotted to them by the Secretary of War and the granting of additional water up to the amount at the disposal of the United States under the present treaty is optional with the Secretary.

Flow of Water over Weirs

Ben D. Moses

Often in practice the weir is used to measure water and its use is purely mechanical to many of its advocates, as the quantity is found generally by looking up the values in tables, picking them off of curves, or substituting in formulas. Unless, then, one is more or less familiar with the theory of the weir itself, quite distressing mistakes are likely to be made.

Nothing is prettier, or will hold the attention as will a sheet of water falling over a well made weir, whether it is small, and used in the laboratory or one spanning a river valley, unless it is the theory of the flow of the water. Then, too, the actual results obtained in the field conform so closely to what the theory predicts that the possession of one begets a desire for the other.

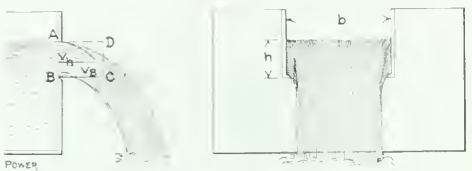


Fig. 1. Rectangular Weir, Showing Velocity Curve

Fig. 2. Triangular Weir, Showing Velocity Curve and Volume

In the use of the weir for water measurement, several things must be assumed as understood:

(1) The velocity of water flowing through a free orifice under a head h, theoretically equals $\sqrt{2gh}$, where g is the value of the earth's pull, or equals 32.2. In other words, if the pressure of a column of water h is converted entirely into velocity, the velocity would be equal to $\sqrt{2gh}$.

(2) Because of friction, eddying and irregularity of flow, the actual velocity will be something less than the theoretical; and,

(3) Because of contraction, the cross-sectional area of the stream will be something less than the area of the notch over which the water is flowing. This phenomenon will effect the quantity Q directly, so that in place of Q being av, it will be some constant c times av.

Keeping these things in mind, consider a stream flowing over, first a rectangular weir h deep and w wide.

Rectangular Weir

The velocity of a particle of water at A (Fig. 1) will be zero, and at any depth h below A will be equal to $\sqrt{2gh}$. Now the abscissas of a velocity curve AC would show the velocity at any depth, while the quantity Q in one second is the volume of a solid having the cross-section ABC and length b or Q equal to the area $ABC \times b$. But the curve ABC is a parabola, since its abscissa at any point is numerically the square of the ordinate, and the area of a part of any parabola is $\frac{2}{3}$ of the area of the rectangle formed by the ordinates and abscissas of the points.

Therefore:

$$Q = \tfrac{2}{3} \text{ area } ABCD \times b$$
$$= \tfrac{2}{3}\, bh \times r = \tfrac{2}{3}\, bh \times \sqrt{2gh}$$
$$= 5.35\, bh^{\frac{3}{2}}$$

This is, however, the theoretical Q; the actual Q has been found to vary from 0.59 to 0.64 of this value. This constant, however, depends upon the condition of the weir and must be determined in any given case.

In general $Q = K\ 5.35\ bh^{\frac{3}{2}}$, where K is the experimental constant.

Triangular Weir

A similar consideration of the velocity curve (Fig. 2), shown shaded, of the triangular notch brings us to the point that.

$$Q = Volume\ ABCD$$

but the volume $ABCD$ can be shown to be

Volume $= \frac{8}{15}\ K\ \sqrt{2gh}$, where K is the ratio $b/2h$

Reducing this now, for the 90-deg. notch, which is the one used most in practice, where $K = 1$.

$$Q = \tfrac{8}{15}\ \sqrt{2gh^5}$$

and introducing the constant for contraction, which for the triangular notch is fairly constant and equals about 0.6

$$Q = 2.56\ h^{\frac{5}{2}}$$

In the above deductions it will be understood that the shaded part representing Q is not the form of the water falling over the weir, as the water is affected by the gravity of the earth. While the above curve is purely a velocity curve, it represents to scale what the ideal case would be if gravity ceased to act the instant that the water passed the knife edges of the weir.

It might be well here to say that often in practice suppressed weirs are used, in which case Francis' formula is generally applied.

$$Q = Cbh$$

in which C is dependent upon the number of contractions.

[For a more extensive treatment of the mathematics of the flow of water over weirs, through notches and apertures, the reader is referred to a series of articles on hydraulics in Power for 1908-9.—Editor.]

ELECTRICAL DEPARTMENT

Motors and Motor Applications

By A. B. Morrison, Jr.

The use of electric motors for driving all classes of machinery is so common that little thought is often given to the conditions under which the machine is to operate or to the characteristics of the motor to be applied to it. A careful study of these two points often discloses the fact that a motor of an entirely different size or type from that first planned should be installed. It is the intention of the present article to show in a general way the important factors which must be considered in deciding the proper size and type of motor to install, then to discuss the operating characteristics of the various types, and finally to indicate the best type for certain classes of work.

To secure the most satisfactory results from motor drive it is essential that the type, as well as the size of motor, be properly adapted to the work contemplated. This is especially important in the case of individual drive where the shortcomings of the motor are more serious than in group drive. Even though the size of the motor may be ample to operate the machine under normal load the installation may be very unsatisfactory because the motor does not develop the proper starting torque or else requires excessive current at starting, the speed regulation may not be suited to the machine or some other inherent fault shows up which makes that particular type of motor unsuited for the work required. While, generally speaking, in many installations there cannot be a choice between direct and alternating current, yet the kind of current available is often not important provided the correct type of motor be selected.

In considering the application of a motor it is necessary to take into account the following, all of which must be carefully analyzed if satisfactory results are to be obtained:

Starting torque.
Maximum torque.
Cycle of operation.
Method of drive.
Type of machine and installation.

It is important first to understand clearly the difference between horsepower and torque. The former is the rate of doing work, while the latter is only one of the quantities making up horsepower. The torque of a motor is sometimes defined as the pull or force exerted at the surface of the armature, multiplied by the radius of the armature. For commercial purposes, however, it is defined as the pull exerted at a certain radius from the shaft center. For convenience this pull is usually expressed in pounds and the radius in feet, which, multiplied by the peripheral speed, gives an expression in foot-pounds which is readily reducible to horsepower. Assuming that the force is applied at a distance of one foot from the center of the shaft so that r (radius) $= 1$, then

$$Torque\ (T) = \frac{hp. \times 33{,}000}{2\pi \times r.p.m.} = \frac{hp. \times 5252}{r.p.m.} \qquad (1)$$

From this it is evident that for a given motor and a given horsepower, the torque varies inversely as the speed. If the first definition of torque is assumed, that is, the force acting at the surface of the armature—it is apparent that the torque would be dependent on the diameter of the armature as well as the speed; whereas, by the second definition, it is independent of the armature diameter. In motor applications one is concerned with the torque exerted on the motor shaft and not at the surface of the armature.

Starting Torque

With a machine having heavy inertia, the required starting torque may be in excess of that required to keep it running after once in operation. For example, a punch having a heavy flywheel or a long lineshaft carrying a number of large pulleys with heavy machines belted from them, is harder to start than to keep up to speed after once in operation. It is possible to approximate the starting torque by fastening a lever to the driving shaft of the machine and measuring the pull in pounds necessary to turn the shaft; this pull multiplied by the radius in feet, measured from the center of the shaft to its point of application gives the torque.

Assuming a concrete case, suppose it requires a torque of 50 ft.-lb. to start a certain machine; also to keep the machine running after it is once up to speed requires 7.5 hp. Conditions may be such that a motor with a full load speed of 1750 r.p.m. can be used. By formula (1)

$$Torque = \frac{7.5 \times 5252}{1750} = 22.5\ ft.\text{-}lb.$$

Hence, to start the machine, the motor must exert a starting torque equal to $50 \div 22.5$, or 222% of normal. An ordinary squirrel-cage induction motor, if the installation were alternating current, would probably not be suitable because of insufficient starting torque.

If a 1150-r.p.m. motor be considered in place of 1750 r.p.m., the torque becomes

$$\frac{7.5 \times 5252}{1150} = 34.2\ ft.\text{-}lb.$$

and the starting torque becomes $50 \div 34.2$, or 146% of normal, for which starting torque, the average squirrel-cage motor of this rating is satisfactory.

From the foregoing it is apparent that if a 1750-r.p.m. induction motor were required because of special conditions, it would be necessary to use a type which would give greater starting torque, either a motor having wound rotor or with a high resistance rotor. Furthermore, the time element is important as regards starting torque, for if the maximum starting torque is required for some time (the machine is slow to start), a type of motor which might answer the requirements if the time of starting were short, would not answer for the longer time.

Maximum Torque

With a heavy planer the torque required at the moment of reversal may be sufficient to stall or to slow down the

motor. Similarly with a heavy punch, in spite of the flywheel, the motor may develop insufficient torque to keep up the speed. The maximum torque is, in a sense, a measure of the overload capacity of the motor, particularly for short periods, although this is not strictly correct, as the maximum torque is developed at a lower speed than that at which the maximum horsepower exists. For longer overloads the heating is, of course, the limiting feature. In cases where a motor is large enough for starting and normal operation, but not large enough for the maximum overload required for perhaps only a second or two, the addition or substitution of a suitable flywheel will sometimes cut down the maximum torque required. In some cases it may be necessary to install a motor larger than necessary for the average work simply to secure the maximum torque necessary to keep the machine up to speed at all parts of the cycle.

Cycle of Operation

The cycle of operation required of a machine driven by a motor has an important bearing on the proper size to install. The allowable load is almost always limited by the permissible heating, which is proportional to the square of the current which the motor draws from the line, and since this current is a measure of the horsepower the heating is proportional to the square of the horsepower and to the time. In some cases, however, the maximum load may exist for only short periods and while a motor of proper size to drive the machine during the cycle would be large enough so far as heating is concerned, it might not be large enough to handle the maximum load nor to develop the starting torque necessary.

Method of Drive

A motor may be connected to a machine directly through a coupling, by a belt or chain, or by gears. Where a clutch coupling is used it is possible to bring the motor up to speed and then throw in the clutch. This is advantageous where the driven machine may require an excessive starting torque. A direct-connected, geared, or chain-driven motor is subject to all the fluctuations of load of the driven machine, whereas with a belt connection or clutch there is a chance for slippage. This question must also be considered in the case of a number of machines which may be group driven from one shaft or may be individually driven. The choice of group or individual drive may depend largely on the starting and maximum torque requirements of the various machines. If these are excessive they may be better handled by one large motor which has a large starting torque compared to that required by each separate machine, starting the machines one after the other, rather than by a number of smaller motors, built specially for the work.

In the case of alternating-current motors, especially, the question of direct connection or some other form of drive is important as the characteristics of the induction motor are modified considerably by the speed.

Type of Machine and Installation

Even after the size of motor has been checked up by the requirements discussed, it is important to consider the type of machine and the general class of installation. For example, suppose the motor drives a centrifugal pump elevating water to a certain height. A variation in head or speed will greatly modify any test figures given; therefore, allowance should be made and the motor installed of sufficient size to take care of such contingencies. If the installation is in a very dirty place a squirrel-cage motor would evidently be preferable to any other type of induction motor. If the voltage is apt to vary this must be taken into account, particularly with induction motors in which the torque varies as the square of the voltage. If the motor is installed in a hot place it should be larger than if installed under normal conditions.

Alternating-current Motors

By far the greater number of alternating-current motors are of the multiphase-induction type, the construction of which is too well known to need describing in detail. Briefly, these motors consist of a stationary element, or stator, to which the line current is supplied, and a revolving element or rotor, not connected electrically to the stator but which is acted upon by the flux induced by the current in the stator and is caused to rotate at some fixed speed dependent on the number of poles and frequency of the circuit. The great advantage which the multiphase-induction motor possesses over any other type is its simplicity.

There are two general types of constant-speed induction motors—the squirrel-cage and the wound-rotor types. The former is so called because the conductors in the rotor consist of copper bars laid in slots and short-circuited at the ends by metal rings; hence the resemblance to a cage. The rotor conductors in the wound-rotor type are form wound, somewhat similar in appearance to the armature coils of direct-current machines or of alternators, and these coils are connected to collector rings on the shaft. These collector rings are similar to those on alternators and are supplied with brushes from which the rotor currents are led through some sort of controller and suitable resistance. This resistance may be designed for starting duty to remain in circuit only while the motor is coming up to speed, or it may be constructed to remain in circuit continuously, where a reduction in the speed of the motor is desired. It should be noted that squirrel-cage motors are usually constant speed, whereas wound-rotor motors may be either constant or variable speed.

In considering the choice of a suitable constant-speed induction motor for any given installation the standard squirrel-cage motor offers the advantages of simplicity and ruggedness, with no moving parts carrying current; hence a motor particularly suitable for dirty and dusty locations or where sparking might be dangerous. The disadvantage of this type is that the starting torque per ampere of current is low. To develop a starting torque equivalent to full load torque the motor will draw from the line momentarily a current several times that necessary at full load. This is apt to cause considerable disturbance in the line and affect other apparatus connected to it, particularly if the motor is large. If lights are connected to the same line they may flicker badly. All squirrel-cage motors, except very small ones, if started by throwing directly on the line, would take a heavy rush of current. To prevent this a suitable form of starting device, or autotransformer is employed to reduce the impressed voltage when starting. The starting torque, however, is proportional to the square of the impressed voltage, so that it will fall off faster than the current. Hence,

if the motor is to develop a large torque when starting, it will take a comparatively large current from the line at that time.

The maximum torque of induction motors is generally from two to three times full load torque. This maximum torque is independent of the rotor resistance and, therefore, with any given motor, the maximum torque which it is capable of exerting under given conditions will be the same regardless of whether the rotor is of the squirrel-cage type or of the wound-rotor type or any modification of them. So far, therefore, as maximum torque is concerned a motor can be selected with regard to its starting torque only, knowing that the type of motor will have no effect on the maximum torque which is to be developed.

The wound-rotor motor is particularly suitable where the starting duty is severe, where a large current drawn from the line at starting is objectionable, and the installation is in a place free from dust and dirt. The starting current, corresponding to full load torque, is only a little greater than full load current as against four or five times as much in the case of the standard squirrel-cage motor as already noted. The maximum torque is exactly the same for the same horsepower and speed rating. The efficiency of the motor is lower, due to increased losses in the rotor and the drop in speed from no load to full load, or the slip, is greater than in the standard squirrel-cage type.

Where a heavy starting torque is desired and the wound-rotor type is not desirable a squirrel-cage motor with a high resistance rotor may be used. This is similar to the ordinary squirrel-cage motor, except that instead of the low resistance rings connecting the ends of the rotor bars, these end rings are of less cross-section or of a different metal so that their resistance is greatly increased. Since in the commercial induction motor, other things being equal, the starting torque is proportional to the rotor resistance up to a certain point, the construction just described results in a greatly increased starting torque, though the efficiency is lessened and the slip from no load to full load is greater. This type requires very careful construction of the end rings so that the heat developed by the heavy currents in the rotor at the time of starting will not loosen the connections and therefore cause poor contacts.

A significant point inherent in the design of induction motors is that, as the speed decreases, the operating characteristics become poorer. As the speed decreases for a given horsepower rating the magnetizing current of the motor increases so that the power factor is much less for the lower speeds. The efficiency is also decreased, though not as rapidly as the power factor. With a standard squirrel-cage motor the starting torque is also affected, being lower on the slower speeds. Hence, wherever possible, motors of as high speed as possible should be used, not only on account of first cost, but because of better operating characteristics.

From the standpoint of first cost the standard squirrel-cage induction motor is cheapest, the squirrel-cage motor with high resistance rotor next, and the wound-rotor motor is highest.

The use of variable-speed, synchronous, single-phase and direct-current motors will be considered in subsequent articles.

Improving Conductivity of Joints

It is obvious that considerable loss may occur through imperfect metal-to-metal contact on switchboards, especially where the copper is bolted together and the pressure is not very great.

A test made recently at the Laboratoire d'Electricite, on joints made in accordance with the best French practice, showed that on a busbar carrying 1760 amp., 84.5 watts were lost per hour due to heating. In a plant operating 10 hr. per day and 300 days per year, this would represent 253 kw.-hr. per year. While this may not appear large, it should be remembered that this was only one of a number of similar joints on the switchboard.

A preparation has recently been put on the market which is claimed to reduce this loss by about 85 per cent. It is called "Optimus Plastic Alloy," and is in the form of a metal putty, which is a good conductor and fills up all the cavities in the surface; thus, it is claimed the plates are made continuous electrically. It is further claimed that moisture is prevented from entering.

The alloy is put in cold and does not prevent the copper from being separated readily when desired.

Rotary Converter without Shunt Field

I should like to have the opinions of some readers as to what would occur if a loaded rotary converter should suddenly loose its shunt field. What proportion of full load could the machine carry under these circumstances and what would be the probable power factor?

Schenectady, N. Y. N. M. Hill.

Peculiar Motor Trouble

A short time ago upon placing a 10-hp. induction motor in service the following trouble was encountered:

When the compensator was on the starting position the motor, with an ordinary light load of shafting and loose pulleys, would develop about one-third normal speed and with a consequent lack of power. This would not change when the compensator was brought to the running position. If the handle of the starting compensator was thrown quickly from the "off" to the "running" position, the motor would reach almost the rated speed, but the moment the load was thrown on, it would slow down to about three-fourths normal and heat considerably to about 185 deg. F. or 115 deg. above room temperature.

This motor drove two triplex ammonia pumps and two triplex brine pumps, which load is at present being carried by a motor of the same type and size, which shows that it was not an excessive load that caused the trouble.

The motor in question is a three-phase, 60-cycle, 550-volt machine of the squirrel-cage type and is rated to run at 1200 r.p.m. The stator winding consists of 72 coils, arranged in 18 groups of four coils each. The stator winding had just been renewed and the cross-connections were made in exact accordance with the manufacturer's drawing for Y-wound motors of this type. A voltmeter test indicates a ground of 20 volts, but I do not think that this would cause such conditions to exist.

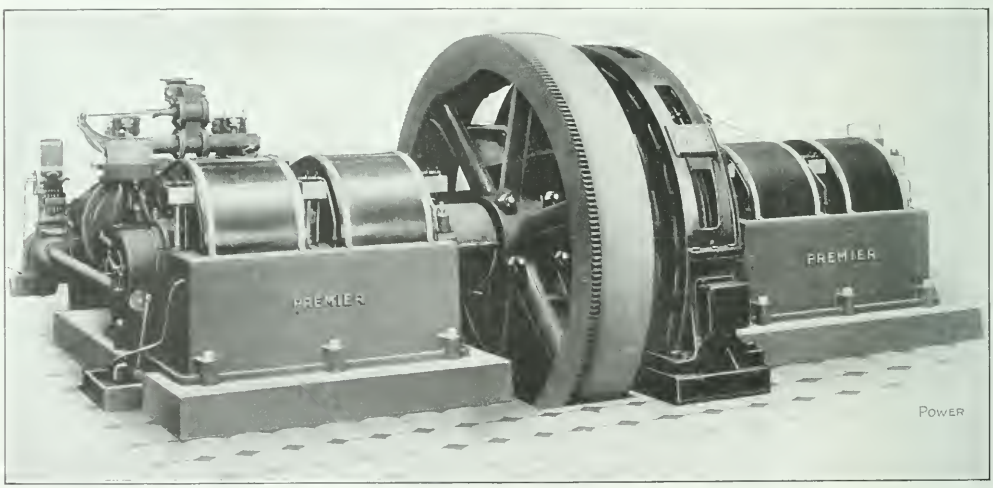
I have examined the rotor for loose bars and it is in good condition, as was the starting compensator, nor do the bearings show any signs of wear.

Washburn, Wis. F. L. Bryant.

GAS POWER DEPARTMENT

A Korean Gas Engine Plant

The application of gas power to industrial activities is finding its way into all parts of the world and, in this connection, it is astonishing with what avidity the newer nations are adopting the most advanced forms of engineering practice which have been developed in the older world. An interesting example of this is found in Japan and Korea, where a number of townships which comparatively recently were highly primitive, are rapidly adapting themselves to the conditions of modern civilization. In many of these, efficient systems of gas and electricity supply are to be found and some of the generating stations or power houses are models of their kind.



One of the Main Generating Units

The Kankoku Gas & Electric Co., in Korea, is a flourishing and progressive company supplying gas and electricity to the city of Kankoku. Its power-house equipment consists of two double Premier gas engines, each direct connected to a 300-kw. alternator. The alternator and flywheel are placed centrally between the two pairs of cylinders of the double twin gas engine, which has four single-acting cylinders working on the four-stroke cycle and there are therefore two impulses per revolution. The illustration shows one of these units.

At present the engines operate on town gas, but they are so arranged that they can be adapted to work on producer gas, should this become necessary. The quality method of governing is employed, a high-speed centrifugal governor driven from the crankshaft controlling the throttle valve for the gas. The gas and air do not mix until about to enter the cylinder. Ignition is obtained by a separate magneto for each machine.

Starting is effected by compressed air, a distributing valve, operated by a cam on the camshaft, supplying air at the right point in the cycle through a check valve opening into the two cylinders. This gear can be readily put into or out of operation at any position and it continues to admit air every cycle until ignition commences, when the admission of air ceases.

Lubrication of the main bearings and crank pins is effected by a valveless oil pump delivering oil to these parts, and drawing it from a tank connected to the crank chamber, after passing through a strainer. The cylinders and exhaust valves are lubricated by a sight-feed arrangement and a small force pump. The small-end bearings of the connecting-rod are supplied in a similar way. This lubrication gives a constant feed after it is once adjusted, which stops when the engine stops and starts when the engine starts. The measured oil drops into the suction side of a small pump which delivers it under pressure to the point where it is required. The gear wheels work in oil-tight cases and in an oil bath and the shaft bearings in these cases are lubricated by the oil thrown up by the wheels, thus keeping a constant stream flowing over these bearings. The other camshaft bearings are of the self-oiling type.

⁂

The Gas Producer and Waste Fuels*

The steam engineer aims at minimum CO and maximum CO_2, while the producer engineer strives for maximum CO and minimum CO_2. A boiler works with a fuel bed usually varying in thickness from 3 to 12 in., whereas the depth of fuel bed in the gas producer varies from

*Excerpts from a paper by F. Fielden, read before the Liverpool Engineering Society, Jan. 8, 1913.

2 to 10 ft. Maximum temperature in the furnace is the ambition of the fireman; on the other hand, a combustion zone of approximately 2000 deg. F., but varying with the nature of the fuel, gives the best results in the gas producer.

In boiler firing it is comparatively easy to deal with clinker, and the tarry volatile gases given off during the coking of the coal are never the cause of trouble at the steam engine and turbine. Stated broadly, however, clinker and tar, are a source of the greatest trouble to the designer of the gas producer.

The earliest application of the gas producer was confined exculsively to heating installations, and only with the advent of the Otto cycle gas engine was begun the adaption of the gas producer to the problem of cheap power production.

The bases of gas production depend on the reactions taking place principally in accordance with the following equations:

$$2\ C + O_2 = 2\ CO$$

(or $C + O_2 = CO_2$ followed by $CO_2 + C = 2\ CO$)

and

$$C + H_2O = CO + H_2$$

If the capacity and design of the suction producer is suitable for the engine, the foregoing reactions are governed entirely and automatically by the load. Since there is no outlet for the gas from the generator except to the engine, it follows that the induction stroke of the engine determines the amount of air and vapor drawn through the fuel bed and consequently the amount of gas produced.

The steam, or vapor supply, has a twofold effect; first, in preventing an abnormal temperature at which the ash would be fused and the firebrick lining burned, and secondly by dissociation, enriching the gas with hydrogen. This steam is generally obtained from the sensible heat of the gas in its transit to the cooling and cleaning scrubber.

Since it is necessary in either a steam boiler or a gas-producer installation to make allowances for fuel consumption during standby hours, the consumption at full load is not the only factor. The standby consumption per hour with a well designed suction-gas producer plant is about 2 per cent. of that at full load. With a steam-boiler installation the standby consumption per hour is nearly 15 per cent. of that at full load.

In the classification of coal, bituminous coal comes between lignites, at the lower end of the scale, and anthracite at the upper end. A general classification as to volatile matter is as follows:

Anthracite up to 8 per cent. volatile matter.

Semi-anthracite, 8 to 10 per cent. volatile matter.

Dry steam coal (navy), 10 to 11 per cent. volatile matter.

Semibituminous, 11 to 20 per cent. volatile matter.

Bituminous, 20 to 40 per cent. volatile matter.

To the gas-producer designer, difficulties are intensified. For power purposes the gas must be clean and free from tar, and of consistent quality. Hot burning coal must be fed with a liberal supply of steam to reduce ash fusion and clinker formation; also, arching over of caking coal must be prevented and a close fire of sufficient density maintained for the reduction zone.

In the same generator it is practically impossible to gasify with commercial success every grade of bituminous coal. An area of combustion zone giving a combustion of 20 lb. to the square foot is ample for Nottingham slack, whereas for Denver slack, double this area is required.

The assistance of the analytical laboratory is necessary to the designer in the adaption of the producer to the requirements of bituminous coal. The chief stumbling block, however, is tar trouble, with its accompanying effect on the working of the gas engine. Sticky valves and piston rings and throttle ports are the direct cause of irregular working and ultimate stoppage of the engine. Many attempts have been made to fix the tar in the form of an incondensible gas in the producer itself by employing down draft or up and down draft in which the products of distillation are made to pass through an incandescent mass of carbon, but up to the present only partial success has been attained. Some firms prefer to extract the tar from the gas externally by means of a centrifugal tar extractor.

During the past five or six years the bituminous suction plant has been successfully applied to the gasification of waste fuels, and pioneer installations are at work dealing with sawdust, wood refuse, spent tan, cocoanut shells, coir dust, cotton seed cake, coffee and cocoa husks, smoke-box char, olive refuse, etc. While some of these fuels have been employed for boiler firing, the consumption per brake horsepower-hour is two to four times that of the suction-gas plant. On the other hand, it has been found necessary to use coal with some moist fuel, such as spent tan and wood refuse, in order to get the necessary temperature in the boiler furnace. A moisture content of 50 per cent. appears to be no detriment to gasification in the correct design of producer.

Such fuels as smoke-box char, weighing 50 lb. per cu.ft., demand a different design than that for such fuels as fine sawdust or husks. The former demand an excessive area of cross-section with a minimum depth of fuel bed, and an average velocity of gas when leaving the top of the fuel bed. On the other hand, the sawdust and light fuels require a maximum depth of fuel and a minimum velocity of the gas as it leaves the fuel bed, to prevent pulling over the raw fuel during the induction stroke of the engine.

The essential difference in the relative combustion of light, moist fuel in a gas producer as compared with a steam boiler seems to lie in the fact that with the former a sufficient temperature at the base of the fuel bed is necessary, together with an adequate density of incandescent carbon and the requisite velocity of the air and vapor through the fuel bed to effect reduction; while with the steam boiler radiant heat is what is most desired. To obtain this it is necessary to drive off all moisture which at once extracts heat from the boiler, and at that particular stage of the process when the top layer of fuel is in a combustible state the draft is sufficient to draw the carbonized particles away along the flues and even up the stack.

That the gas producer is one of the most commercially profitable means for the utilization of waste fuels is shown by the large number of such installations now in operation. At the Highfield tannery, at Roencorn, an installation of 100 hp. has been working for some years on spent tan alone, with such satisfaction as to warrant the recent duplication of this unit. A more recent installation, the largest in the world for dealing with this

waste product, is one of 700 hp. now being erected at Ditton, in which 300 hp. is to be used for power purposes, and 400 hp. for combustion under existing steam boilers. With a moisture content of 50 per cent., the consumption per brake horsepower-hour amounts to approximately 3½ lb., and the gas produced from this weight of spent tan is from 70 to 80 cu.ft., at approximately 125 to 135 B.t.u. per cu.ft.

In a recent test of a 75-hp. wood producer plant, employing chippings and wood waste as fuel, a brake horsepower-hour was obtained with 2.64 lb. of refuse. This fuel had a heat value of 163 B.t.u. per lb., and the engine at the time was running at 15 per cent. overload.

Test on Diesel Engine Using Tar Oil

A 325-hp. vertical, single-acting, four-stroke-cycle Diesel engine running 167 r.p.m. in the Hamburg-American Watch Factory, at Scharmberg, Germany, was recently tested by the Wurtembergische Revisions Verein in Stuttgart. The engine is direct connected to a three-phase generator, the two single-stage air compressors being driven directly from the shaft. A series of tests at one-fourth, one-half, three-fourths and full load, as well as at 10 per cent. overload was made to ascertain the fuel consumption, including the gas oil, which is used in starting. The results of these tests are graphically shown in the accompanying diagrams. The highest output attained was 240 kw., or 355 effective horsepower from the engine, which is 10 per cent. more than was guaranteed.

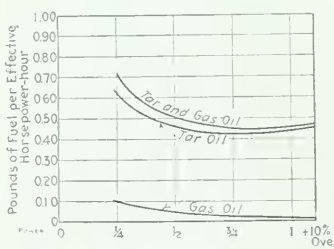


Fig. 1. Fuel Consumption vs. Load

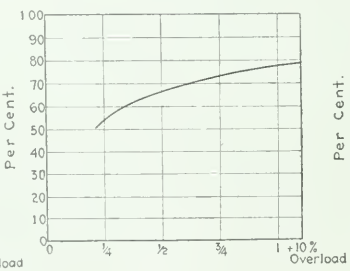


Fig. 2. Efficiency vs. Load

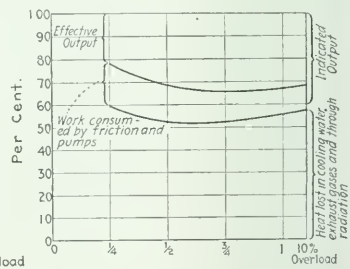


Fig. 3. Heat Balance with Different Loads

With fuel prices such as obtain in Germany the cost per kilowatt-hour figures 0.35c. per kw.-hr., or 0.23c. per effective horsepower.

Fig. 1 shows that the most favorable fuel consumption occurs between three-fourths and full load and remains nearly constant, which speaks well for the operating economy of the Diesel engine. Fig. 2 shows that the mechanical efficiency at full load is about 77 per cent., and at 10 per cent. overload about 78.5 per cent. These figures reflect favorably on the construction and lubrication.

Fig. 3 is a composite plot of the heat balance for various loads. It shows that about 55 per cent. of the heat contained in the tar-oil fuel is lost in cooling water, exhaust gases and through radiation, while at full load about 34 per cent. is gained as useful work, the rest being absorbed by the pumps. This diagram also shows that the most favorable operating conditions are obtained between three-fourths and full load.

CORRESPONDENCE

Drying Out Magnetos

The company with which I am employed operates a number of launches, having magnetos of the three-bar permanent magnet type for ignition purposes. Not long ago the magnetos began to give trouble, which upon test, proved to be due to salt-water grounds in the armature. As the magnetos are friction driven from the flywheels of the engines, they were installed at about the same level as the engine base, which made them subject to all the dampness and salt water that accumulated in the bottom of the boats.

The trouble was remedied in the following manner: The pole-pieces were cleaned and shellacked; then the armatures were put in a pot of boiling water and allowed to boil for about 20 min., after which they were baked in a crude, but successful, manner by suspending over the stationery boilers for 24 hr. They were then shellacked thoroughly and allowed to bake another 24 hr., after which they were assembled, and have given no further trouble.

Oakland, Calif. J. T. Brown.

Pound in Engine Cylinder

Replying to the inquiry of Mr. Able, in the Jan. 28 issue, as to the possible cause of the pound in his oil engine, I would suggest that he examine his engine for carbon deposits on the cylinder head and piston.

I have had experience with cases similar to his, particularly with engines using low-grade fuels, and the cause was usually carbon deposits; although, in one instance, it was a burr on the cylinder head which, when heated, caused preignition. This gave no trouble until the engine had been in service some time, as the cooling water kept the burr below the ignition temperature, until the water jacket became badly scaled from the cooling water.

In either event, the engine would act the same, for the mixture being ignited by the incandescent carbon or the burr, advancing or retarding the spark would have no effect. At light load, the compression would not be high enough to cause ignition to occur early enough to cause a pound, and, when using too rich a mixture, the combustion would be too slow and weak to cause a pound.

Rush City, Minn. C. W. Foster.

REFRIGERATION DEPARTMENT

A New Refrigerating Cycle

By Oscar P. Ostergren

Carbonic-acid machines, when operated as at present, have shown surprisingly good practical efficiency—a fact that should encourage further efforts toward improvement. The ratio of compression is not so great as in the ammonia machine, which is an important consideration. The losses at the regulating valve, however, must be greater. So, also, is the loss due to the mechanical efficiency of the machine on account of the unusually high pressure required. To lower this pressure is the object

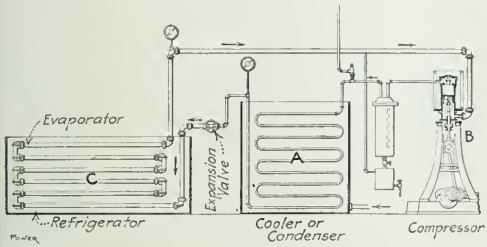


Fig. 1. Connections of Ordinary Compression System

of the proposed cycle. Fig. 1 shows the usual compression system and Fig. 2 the new cycle.

Referring to Fig. 2, carbonic anhydride in a gaseous state enters compressor *A* through suction valve *a*, where, after compression, it is discharged through valve *b* into oil trap *c* and cooling coil *d*, where it is cooled by water in the regular way. From *d* the gas enters the counter-current cooling apparatus *B*, which may be termed a "precooler," and is then conveyed by the inner pipe *e*, through *B*, to a second and similar apparatus *C*, which will be called a liquifier. The gas passes through the inner pipe

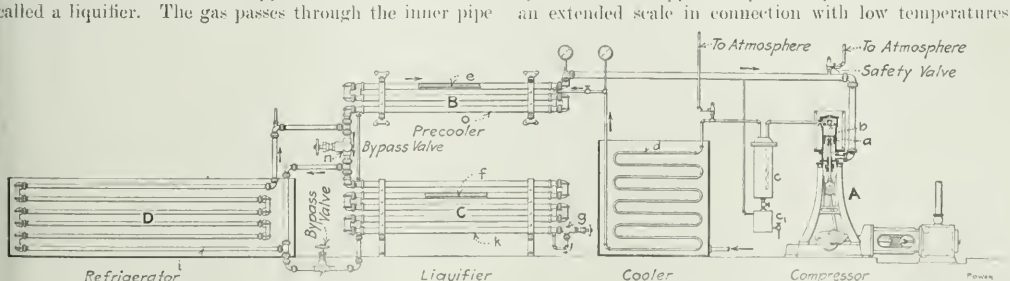


Fig. 2. Diagram of Apparatus for New Refrigerating Cycle

to the expansion valve *g*. In pipe *f* the gas or vapor is condensed into the liquid state at a comparatively low temperature. In passing the expansion valve *g*, under a reduction of pressure, part of the liquid is evaporated to reduce it to the temperature existing in part of the liquifier. From the valve, the mixture of liquid and vapor enters the exterior pipe *k* and proceeds to the coils of the refrigerator *D*. In passing through the liquifier, heat is taken up by the cold mixture from the compressed gas in pipe *f*, which runs in the direction of the expansion valve *g*, thereby liquifying the gas. The transfer of heat in the liquifier should be carried to the extent that the CO_2, when entering the refrigerator, is at the desired temperature. This can be regulated as desired by means of by pass valves *m* and *n*. If a lower temperature is needed, *m* is opened and also *n*. Less gas will pass through the refrigerating coil *D*, but it will be of lower temperature. Having passed through the refrigerator, where heat has been taken up from the body to be refrigerated, the refrigerant now enters the exterior pipe *o* of the precooler, where still more heat is taken up from the refrigerant, which is going toward the liquifier. From the precooler, it returns to the compressor at nearly the temperature of the cooling water. In this system it will be possible to get any desired temperature in the refrigerator between that of the cooling water and a point somewhat above the solidifying or freezing point of the refrigerant without any other change in the arrangement than some adjustment of the expansion valve *g* and the bypass valves *m* and *n*. With this regenerating process, the refrigerant can be liquified at any practical pressure. The back pressure (low pressure) may be anything desired. The process is also practical when the cooling water is of relatively high temperature and should, on this account, be of special value in hot countries. The system should lend itself particularly to small refrigerating plants and also to special low temperatures. It is practically out of the question to operate a very small compressor continuously against a pressure of over 1000 lb.

While the above process is, so far as the author knows, original with him, it is not entirely new. Several years ago, he had the opportunity to carry on research work on an extended scale in connection with low temperatures, where large quantities of many of the so called permanent gases were liquified, including atmospheric air. Some compound gases, such as the air, illuminating gas and even gases from combustion in an ordinary furnace, were cleaned and separated into their component parts by means of partial liquification. Even 15 years ago, it was

quite plain to the writer and others connected with this kind of work that great improvement in the efficiency of liquification cycles could be obtained by precooling the liquid refrigerant before expansion. In this way, it was possible to liquify air at a pressure of about 800 lb. or even less; whereas 3500 lb. had been used. Without the regenerating process, it would have been necessary to use a pressure of 10,000 to 12,000 lb. per sq.in.

Carbonic-acid refrigerating machines are taking a prominent part in the refrigeration of ships today, supplanting both the ammonia and dense-air machines. There seems to be no reason why their use should not be extended to railroad refrigeration on a large scale. They possess many qualities which the ammonia machine lacks and, with some further improvement in their thermal efficiency, and the reduction of the working pressures to practical limits, they should prove to be a formidable, if not superior, rival of the latter.

[The new refrigerating cycle described in this article is intended to be based on the construction of the machines used for manufacturing liquid air, and while such a system for practical refrigeration would require a great deal of power per refrigerating unit, it is here presented, as the suggestion on reducing the operating pressure may be worthy of some consideration.—EDITOR.]

Avoidable Accidents in Refrigerating Plants*

BY LOUIS BLOCK

It is the custom to test ammonia piping with air pressures of from 250 to 300 lb. per sq.in. before charging the system with ammonia. The inexperienced operator is apt to meet with an explosion, when the air temperature reaches 500 deg., and this may occur as soon as the pressure has reached 110 lb. The usual mode of procedure is to lubricate the cylinders in the ordinary manner with mineral oil, which is thereafter to be used in the refrigerating system. This oil is eventually discharged by the compressor into the piping, where it lodges in some pocket, and finally when a sufficient high temperature reaches this pocket, is vaporized and ignited.

I advise covering the cylinder walls with a thin coating of lard oil, using the hand to apply it; then compressing up to 100 lb. and stopping long enough to allow the compressor to cool; then running up to 150 lb., and again stopping to let the compressor cool. After this the compressor should be operated at a slow speed and stopped as soon as the discharge pipe becomes so hot as to make it impossible to keep one's hand on it for a period of a minute.

A number of operating engineers have the habit of pouring hot water over the ammonia shipping drums to facilitate the charging of the ammonia into the system and some that have a steam jet handy let steam impinge against the drum, or they sometimes wrap cloth around it and stick the end of the steam hose under the cloth. If the engineer turns off the valve on the pipe connection between the shipping drum and the charging pipe and goes to lunch, forgetting to turn off the steam, the drum will probably explode.

*Abstract of paper read before the American Society of Refrigerating Engineers, New York City.

Ammonia gas from leaks, due to the breaking of a pipe, flange or fitting, when there are lights or any other open flame present, may ignite and fill the entire engine room for a few seconds with fire. Such accidents can positively be prevented by having nothing but incandescent lamps in the engine room.

The breaking of compressors may be due either to leaving the stop valve in the discharge pipe shut when starting up, or to dropping a valve into the compressor. The former class of accident may be prevented by installing the usual bypass and safety valve. To prevent the latter class of accident, use valves having hollow stems wherever possible. Anneal the valves every year and throw them away after they have been in use five years.

The breaking of crossheads in steam engines is usually due to water in the cylinder and may be prevented by superheating the steam or installing an efficient steam separator close to the engine.

The following rules may be worth remembering:

Don't use a compressor which has been used for ammonia compression, for compressing air.

Don't calk a fitting while under ammonia pressure.

Don't stand in front of a steam cylinder or compressor unless it is absolutely necessary.

Rating a Compressor

The French Association of Refrigeration, in the *Bulletin* of the International Association, expresses the wish that the following definitions should be adopted:

1. The normal power of a refrigerating machine is the number of frigories* it can absorb in one hour for gas temperatures of 77 deg. F. at the condenser, 59 deg. F. at the expansion valve and 14 deg. F. at the refrigerator.

2. The specific volumetric production is the number of frigories really absorbed at the refrigerator by each cubic meter of gas drawn in by the compressor.

3. The volumetric efficiency is the relation between the number of frigories really produced by the suction of the unit of volume of vapor and the number corresponding to the cycle of Carnot.

4. The specific economical production by the number of frigories produced per indicated horsepower of the compressor.

5. The economical yielding by the report of the specific economical production similar to that of a machine realizing the cycle of Carnot.

Ice Machine Racing

In reference to the inquiry on this point, appearing in the Dec. 24 issue, it has been my experience on a 150-ton compressor that after a certain speed, which will vary a little with different suction pressures, enough gas will not be obtained through the suction valves to fill the cylinder to its full capacity. The cylinder not being filled to its capacity, there is less gas to compress and less work to do, so that the engine will tend to run away. I have had an engine race badly by speeding up an overloaded machine in an attempt to get more work out of it.

Revere, Mass. R. B. ROWE.

*One frigory per hour equals 0.00033 American tons per 24 hr.

EDITORIALS

Caring for Condenser Apparatus

Many engineers carry too high a vacuum in condensers serving reciprocating engines and too low a vacuum in condensers serving turbines.

Because, under usual conditions, it is difficult to maintain a satisfactory degree of vacuum without paying careful and constant attention to the condensing apparatus, some think that the higher the vacuum maintained the better it speaks for the engineer in charge. Theory shows, and practice proves, that, with reciprocating engines operating under everyday conditions, there is a decided gain in the economy or water rate of the condensing engine up to a vacuum of between 26 and 27 inches. Tests of a 5500-horsepower engine at the Waterside station of the New York Edison Co., made during 1904, showed that when the vacuum was increased from 25.3 to 27.3 inches, the water rate decreased only 0.06 pound per indicated horsepower. The tests and the results may be considered typical of what may be expected of any reciprocating condensing engine. The operating engineer should remember that, with degrees of vacuum of over 27.5, or at most 28 inches, the increased loss due to cylinder condensation goes far toward nullifying the gain due to a better vacuum. Cylinder condensation is caused by the alternate heating and cooling of the cylinder walls at each stroke of the engine. On the exhaust stroke, the cylinder is, of course, cooled considerably and, when live steam is admitted and encounters comparatively cold cylinder walls, it gives up a part of its heat, which, neglecting the small amount restored by reevaporation during expansion, is lost as far as doing useful work is concerned.

As we all know, the condensate should be returned to the boilers at as high a temperature as possible consistent with the best degree of vacuum. The higher the vacuum carried, the lower will be the temperature of the condensate or hotwell water. For example, at 26 inches vacuum the temperature will be 125.38 degrees Fahrenheit, at 27 inches 115.06 degrees, or a drop of 10.32 degrees. The drop in temperature from 27 to 28 inches vacuum is 13.91 degrees and from 28 to 29 inches it is 22.08 degrees. Knowing that ordinarily every ten degrees rise in the temperature of the feed water decreases the coal consumption one per cent. we realize the importance of not maintaining too high a vacuum. The temperature of the hotwell water will nearly always be below the figures given above on account of water leaking through the tubes and of other causes.

With turbines, cylinder or initial condensation is practically nil, as the high- and low-pressure ends of the machine are at a constant temperature as long as the initial steam pressure and the vacuum are kept constant. Obviously, then, there is no limit to the degree of vacuum that may be economically carried on a turbine.

After all, a condenser may be considered as a heat exchanger, wherein water, by direct or indirect contact with steam, absorbs heat from it. The more perfect the heat absorption, or exchange, the more perfect the vacuum.

In condenser practice, the chief obstacle to creating and maintaining a high vacuum is the presence of air in the condenser. To insulate a steam pipe, the aim is to surround the pipe with a film made of cells of dry "dead" air. Because air is an excellent thermal insulator, it is as detrimental in a condenser as it is good in a steam-pipe covering.

As the steam condenses in a surface condenser, much of the air in the steam is liberated and left behind. As the process continues, the density of the air surrounding the tubes increases, forming an insulator for the tubes —the density increasing as the bottom rows of tubes are approached.

While the purpose of the air pump is to remove air from the condenser, the engineer should make sure that it is not removing air from the condenser that could be kept out of it by carefully guarding against leaks. When the air pump is worked unnecessarily hard, it means wear and tear of the pump and a higher steam consumption, which is serious in any condensing plant.

In most condensing plants, much of the air gets into the condenser through small but numerous leaks in the condenser shell and piping. The feed water is also a conveyor of air, although it is claimed that where open feed-water heaters are used the air going to the condenser with the steam is greatly reduced.

The sealed glands of the turbine and air pumps admit air if the seal pressure is below normal. The results of tests made to determine the amount of leakage at the seals, were brought out in a discussion of a paper by George A. Orrok, on "Air in Surface Condensation," recently presented to the American Society of Mechanical Engineers.

In the installation tested, the condensers were of the jet type, serving a 2000-kilowatt turbine. At no load, and with no steam on the seals, 86 cubic feet of free air per minute entered the condenser; a corrected vacuum of 26.6 inches was maintained. At about 80 per cent. rated load, and with no pressure on the seals, 91 cubic feet of free air per minute leaked into the condenser, causing the vacuum to fall. With normal pressure on the glands, the leakage fell to 58 cubic feet and the vacuum rose to over 28 inches.

To get an idea of the amount of air leaking into large condensing turbines, Mr. Orrok's accounts of tests in this direction are indeed valuable and interesting.

For units between 5000 and 20,000 kilowatts, the amount of air discharged by the vacuum pumps varies from one cubic foot per minute (free air), when the units are in the best condition, to 15 or 20 cubic feet, when ordinary leaks occur. When the units are in bad condition, the air handled by the air pumps varies from 30 to 50 cubic feet per minute. The above figures show how necessary it is to guard against air leaks.

There is also too great a tendency for engineers not to allow sufficient temperature difference between the inlet and outlet circulating water. The aim should be to make the water absorb as much heat as possible, consistent with maintaining a high vacuum. When this is not done, the steam consumption and the deterioration of the circulating pump are necessarily increased.

Steam, inlet and outlet circulating-water temperatures, time and vacuum readings, taken at short intervals and recorded on a proper log sheet, are about the best means available for knowing how well the condensing apparatus is operating.

Another thing the engineer should bear in mind is this: The cost per kilowatt of high-vacuum apparatus increases much more rapidly than the increase in vacuum maintained by the apparatus.

After Coal—What?

The yearly production of vegetable matter on the earth is estimated at 32,000,000,000 tons, which if burned would yield a quantity of heat equal to that obtainable from 18,000,000,000 tons of coal—that is to say, eighteen times as much heat as is furnished by all the coal now mined in Europe and America.

Is it not to be supposed that the production of plant substances may be so increased and intensified in selected regions as to supply all the fuel we can possibly want in the future? We are now using for fuel purposes fossil solar energy in the form of coal. Why not utilize instead live solar energy?

Plants should be made to store up solar energy for conversion into mechanical energy. The kind of plants used is of no consequence. They may be grasses or trees; they may grow in swamps or dry places, on the seacoast or even in the sea. The essential point is that they shall grow fast or that their growth shall be accelerated.

The production of plant substances over all the land surfaces of the earth averages one ton to the acre. By intensified culture it could be made four tons. This on one square mile would amount to 2560 tons, corresponding to about 1400 tons of coal.

In an epoch soon to arrive the harvest of fuel plants dried by the sun may be converted entirely into gas for fuel purposes, separating out the ammonia, to be returned to the soil as nitrogenous fertilizer, together with all the mineral substances contained in the ashes. The gas thus obtained may be burned on the spot in gas engines or otherwise and the mechanical energy generated by this means be transmitted over great distances or utilized in any way that seems advisable. Even the carbonic acid resulting from combustion could be returned to the fields, so that the latter may lose nothing of their productiveness.

By this method the radiant energy of the sun may be made to furnish low-priced mechanical energy, plants (instead of the mirrors with which promising experiments are now being made in Egypt and Peru) being used as accumulators.

Few people have any notion of the vast quantity of live solar energy available for use. In the tropics with a day of six hours' sunshine, the sun delivers upon one square mile per day an amount of heat equal to that obtainable from the burning of 2500 tons of coal. A surface of 10,000 square miles receives in a year at this rate a quantity of heat equivalent to the burning of 9,000,000,000 tons of coal—which is nine times the total amount of coal mined in Europe and America in a twelve-month. The Desert of Sahara, with an area of 2,380,000 square miles, receives daily solar energy equal to 6,000,000,000 tons of coal.

Compared with this live solar energy the quantity stored up by plants in ancient geologic epochs in the form of coal is trifling.

Recent discoveries of science have proved that sunlight itself may be utilized to develop immense energy. Accordingly it is suggested by Professor Ciamician that desert regions of the tropics, where conditions of soil and climate render it impossible to grow crops, shall be made to employ the sun's rays through the medium of photoelectric batteries, or even photochemical batteries, delivering energy equal to that of billions of tons of coal.

Solar energy is not evenly distributed over the surface of the earth. There are privileged regions in the tropics which would become vastly prosperous if the sun's rays were suitably employed. Even now the strongest nations are rivaling one another in the conquest of the lands of the sun as if unconsciously looking to the future.

Where vegetation is profuse, solar energy may be utilized through plant growth for industrial purposes—that is to say, for the production of mechanical power. In desert regions unadapted to any kind of cultivation, photochemistry will artificially put the sun's rays to practical uses.

On arid lands will spring up industrial colonies without smoke and without smoke-stacks. Forests of glass tubes will extend over the plains.

Coal offers to mankind solar energy in its most concentrated form. Indeed, modern civilization may be said to be the daughter of coal. But the supply of coal is not inexhaustible and every ton of it taken out of the earth leaves just that much less for the future needs of the world. Hence it is that today we are looking about us so anxiously for some other source of fuel.

John Fritz

What may be accomplished by earnest endeavor is strikingly shown in the life of John Fritz, a sketch of which is given on page 284.

At the age of sixteen, with what today would be considered a very meager education, he entered upon his mechanical career. The production of iron by modern methods had just begun, steel was practically unheard of, and structural steel was unborn. To commercially produce steel required more knowledge than the chemistry of it; machines subject to exceptional strains and stresses, and the design of which was unusual were required. The Bessemer and Siemens-Martin processes were tantalizingly slow in practical development, and American firms were, therefore, handicapped in competing with foreign manufacturers. Mr. Fritz, more than anyone else, was responsible for the successful development of these important proceses in the great steel industry of this country.

Engineering and scientific societies the world over have honored him, and both they and the steel industry will feel the loss of one active for nearly a century in engineering progress.

READERS WITH SOMETHING TO SAY

Improper Boiler Repair

That improper boiler-repair work is sometimes done if the workmen are not carefully watched, is shown by the following:

One of the main 1¾-in. diagonal stays was found to be cracked half way through in the shank weld, as shown in Fig. 1.

The brace was taken out and another made, using the old one as a pattern. The stay had a thread cut on the end going through the front head and was held in place by a 4-in. washer, both on the inside and outside of the

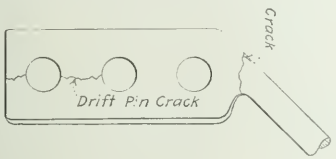


FIG. 1. CRACKED DIAGONAL STAY

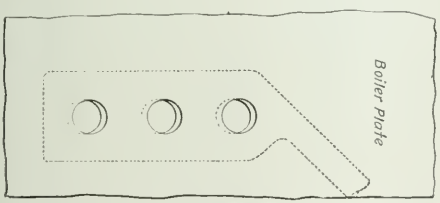


FIG. 2. SHOWING POOR ALIGNMENT OF HOLES IN PLATE AND STAY

front head. The nuts were set up solid, making the stays fast to the front head, while the rivet holes were marked on the end. Then the stay was taken out, the holes drilled and the stay put back. Noticing that the holes did not come even with the old ones, as shown in Fig. 2, by the dotted line, I spoke to the repair man about it. He laughed, saying that he would soon fix it. As I expected, he was going to "fix it" by using a drift pin and a heavy sledge hammer, but I insisted that he hammer the shank until it had increased in length $\frac{3}{8}$ in., making it long enough for the holes to register.

This incident illustrates the necessity of the plant engineer closely observing the repair work being done in his plant by outside men.

A. C. WALDRON.

Revere, Mass.

Value of Engine Inspection

The value of a systematic inspection of engines is frequently shown by the inspection reports. A recent inspection of a 15 and 30 by 18-in. high-speed compound-condensing engine revealed the fact that the high-pressure piston head had an opening about ½ in. in diameter through the side, and a little probing with a wire showed a much larger hole on the opposite crank-end side. The head was of the plain type without bull ring or follower plate, the chambers being cored out to lighten it. The piston was taken out, and a light tap with a hammer enlarged the hole to about 1½ in. in diameter. It was then seen that the walls of the piston were very thin, and lying at the bottom of the chamber was a piece of steel about ⅜ in. thick, and 1¼ in. square.

An examination of the chamber showed the source from which the steel plate came. When making up the mold for this casting the foundryman had to support the core that is used to form the hollow chamber. To do this he used a small piece of metal, known as a chaplet. When the metal is poured it flows all around this chaplet, so that it becomes practically a part of the casting. In this case the piece of steel was much larger than it should have been, and did not unite with the cast iron. When the machinist removed the metal from the face of the piston he cut through the chaplet leaving the inside piece loose, which fell down inside the chamber, and by being so rattled due to the motion of the piston had finally made a hole through the side of the casting.

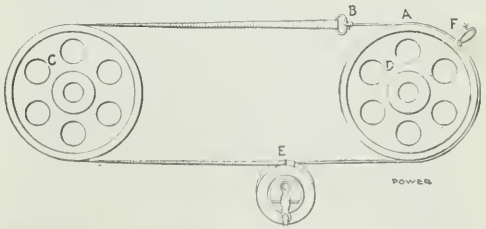
In this case, no great harm was done, only some steam lost, but if the chaplet had worn the hole large enough to allow the chaplet to get through and fall between the moving piston and the cylinder heads it would have undoubtedly caused trouble. The inspection in this case showed the defect before serious harm was done.

ARTHUR CLIFTON.

Joliet, Ill.

Belt Measuring Kink

Most engineers are familiar with the difficulties of accurately measuring the length of a belt with a string, especially when the shafting is in motion. Due to the



MEASURING FOR LENGTH OF BELT WITH NON-ELASTIC TAPE

amount of stretch (unknown) of the string, this method of measuring is a sort of hit-or-miss proposition.

These inaccuracies may be overcome by using a steel measuring tape, as shown in the illustration.

To measure, tie the string *A* to the ring *B*, which is on the end of the tape, pass the tape around the stationary pulley *C* and the string around the running pulley *D*, note the reading of the tape at *E*, add the string length

BE, and obtain the length of the belt. The knotted loop *F* is to facilitate holding the string on the running pulley. When measuring, the loop should be held between the fingers; it is dangerous to slip the fingers into the loop.

CHARLES HERRMAN.

New York City.

Placing a Large Suction Pipe

The accompanying illustration shows how a 48-in. suction pipe, 24 ft. long, of a large pumping engine was handled under difficult circumstances. It was made in two parts: the bottom piece was 10 ft. 9 in. long, bell-shaped at the bottom and flanged at the top. The upper section was 13 ft. 3 in. long and weighed 7 tons. As the building had been erected and the roof and other floors finished, it was necessary to pass those pipes through a hole in the foundation's wall. Some idea of the size and position of the pipe after entering the hole is shown in Fig. 1.

A platform was erected on top of the pump chambers to hold the hoisting crab, which was held in position by tying to a 2½-in. eye-bolt, screwed into the top of one of the adjoining pump chambers; also by passing a length of 2½-in. pipe through the openings in the crab and through two eye-bolts in the top of the chambers. As the suction well was only 12 ft. square, with smooth vertical walls, and an opening 4 ft. square in the center of the floor, it was necessary to place the lower half of pipe in a nearly correct position, so that there

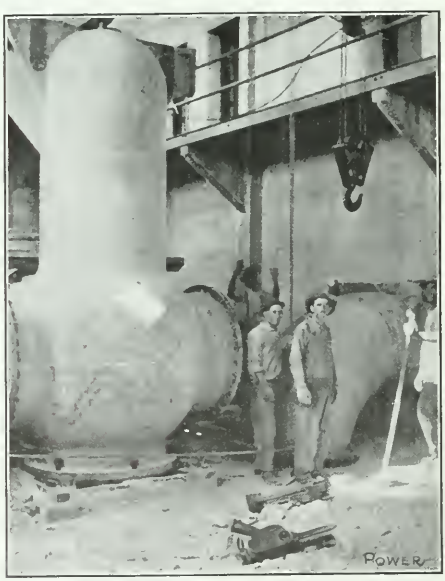


FIG. 1. SHOWING SIZE OF PIPE

would be as little moving as possible when making the final connections, to the pump.

An elevation of the suction well is shown in Fig. 2 with the floor above. In hoisting the pipe two tackles were used. The tackle block was inverted, and the hoisting rope passed through a snatch block to the hoisting crab. Two pieces of ⅝-in. steel cable were used for slings. Three turns were made around the pipe and two turns of the sling were passed over the hook of the tackle block, the third turn was made to haul taut to prevent slipping when lowering the pipe.

After lowering as far as conditions would allow, the load was shifted to the second tackle, and the hoisting tackle made fast, as shown by the dotted lines, Fig. 2. The elbow was then hoisted into position over the lower section of the pipe, a gasket put in place, and the pipes

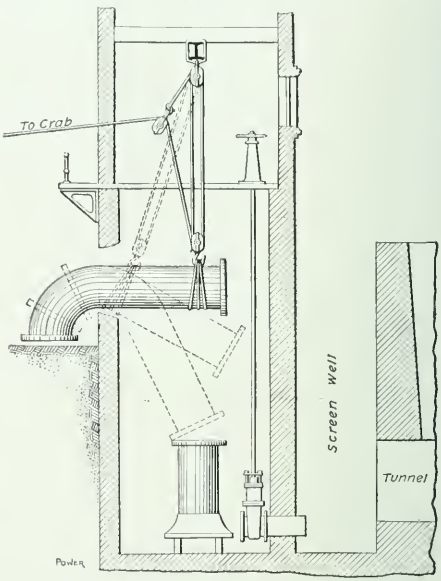


FIG. 2. PUTTING THE PIPE IN THE PIT

bolted together and connected to the condenser and stop valve. The suction pipe was moved to its correct position by hydraulic jacks. After the final connections were made, the opening in the wall was closed with cement.

JOHN F. NAGLE.

Troy, N. Y.

Problem in Power Plant Economics

A local company built an addition to its factory and at that time its plant consisted of a 5-ft. horizontal return-tubular boiler and a four-valve engine of 150 hp. This engine was running at about 90 r.p.m. and cutting off at ¼ stroke.

When the power equipment for the new addition came up for consideration, the management decided to use individual motors on the large machines and to group the small machines so as to be driven by one motor. A 250-kw. alternating-current generator was purchased and was to be driven by the same engine that was formerly used. Another 5-ft. horizontal tubular boiler was also purchased.

The heads of the firm were told at the time they bought this generator that the engine was working at its most economical point of cutoff and that it would not carry the load of this generator. The management claimed

that the engine would take care of the load from the new addition without any trouble.

As the new addition was started up one floor at a time the load came on gradually, but there finally came a day when the fireman could not hold the steam up to 110 lb. for more than a half hour at a time. The maker of the engine was then asked to send a man to indicate the engine.

The first diagrams taken showed that the engine was developing 230 hp. From the diagrams it was difficult to tell where the admission or cutoff took place, in fact, they could have been easily drawn with a square and a pencil.

The man from the engine manufacturer advised speeding the engine up to 118 r.p.m. and increasing the steam pressure to 130 lb. Now the question is, outside of danger from flywheel accident, due to overspeeding the engine, and knowing that the engine will do its work most economically at ¼ cutoff, is it cheaper to run it overloaded, taking steam at more than three-quarters stroke every revolution, or would it be cheaper to buy a new engine?

L. W. CHADWICK.

Bridgewater, Mass.

Combined Supply and Discharge for Tank

The illustration shows a simple arrangement of piping and fittings for a tank where it is desired to automatically prevent overflow, and at the same time permit the use of a single pipe to serve for both supply and discharge line.

Referring to Fig. 1, the pipe *A* extending through the bottom or side of the tank has on its inside end a balanced lever valve *B* operated by the float *C* in the usual manner.

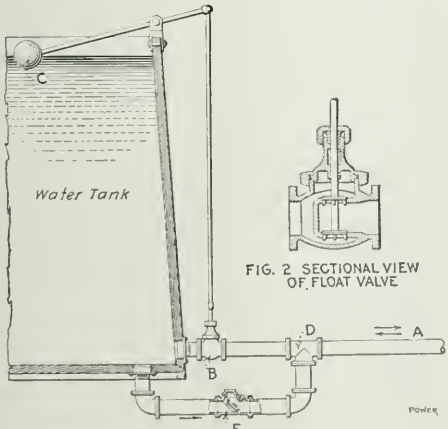


FIG. 1 SINGLE PIPE AS SUPPLY AND DISCHARGE LINE OF WATER TANK

FIG. 2 SECTIONAL VIEW OF FLOAT VALVE

Obviously if the float valve alone is used the pipe *A* could not be used as a discharge pipe after the float has closed the valve unless other means were used to open the valve. To overcome this difficulty the tee *D* is inserted and a bypass run into the tank, as shown. In the bypass there is a check valve *E* so placed that the water can flow from the tank, but not in the reverse direction.

When the water reaches its highest level in the tank both vavles will be closed, preventing overflow. If now the source of supply is cut off and an outlet from the pipeline opened the pressure will fall at the discharge end of the check valve, and the water will flow freely through the bypass as well as through the float valve when the float has dropped sufficiently to open it. A sectional view of the float valve is shown in Fig. 2.

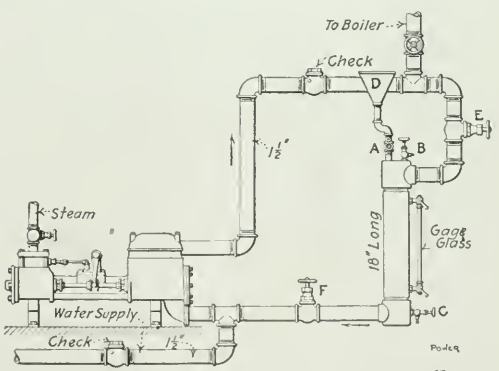
I have used this arrangement in an accumulator tank for gas-engine cooling water, providing for continuous operation while the circulating pumps are shut down for short periods, and in this case there was effected a saving corresponding to the cost of 700 ft. of 8-in. separate return pipe.

W. S. MAYERS.

Fairmont, W. Va.

Boiler Graphite Feeder

The accompanying illustration shows the receiver and piping made for use in connection with the boiler-feed pump to deliver graphite to the boilers. This arrangement works very well, as it not only feeds the graphite to the boilers in the most desirable manner, but it so well lubricates the packing in the pump that the packing gives from two to three times the service that it did before using graphite.



COMPLETE CONNECTIONS FOR BOILER GRAPHITE FEEDER

To fill the receiver, first open valve *A* and the air cock *B*, also open valve *C* to let the water out of the receiver. When it is empty, valve *C* should be closed. Mix the graphite with water until thin enough to pour through the funnel *D*. When the receiver is full, close the valves *A* and *B*, open valve *E*, and regulate the feed of graphite by opening valve *F* as much as is required.

As seen from the illustration, this 3-in. receiver and its connections may be easily made by the engineer from pipe and fittings found about the plant.

J. W. SPALDING.

Seattle, Wash.

The American Society of Mechanical Engineers will underwrite $5000 or its proportionate share, in connection with the International Congress to be held in San Francisco in 1915, provided the other American societies make similar provision.

QUESTIONS BEFORE THE HOUSE

Four Pass Boilers

The plan of using four passes in steam boilers, referred to in the September 17 issue, is open to objections greater even than the greater draft required, the additional baffle to be kept tight, the larger setting and consequent greater infiltration of air, etc., which were mentioned.

Most important is that the additional surface will not as a rule pay for itself. This may be demonstrated from facts cited in the editorial, since it states that the additional fourth pass will reduce the temperature of the gases by 25 to 50° F. This may sound large in degrees but does not show up so much when reduced to percentage of fuel saved, for with the ratio of air to fuel ordinarily attained in good practice nowadays, 25 to 50° F. drop in the flue gases means only 1 to 2½ per cent. of fuel.

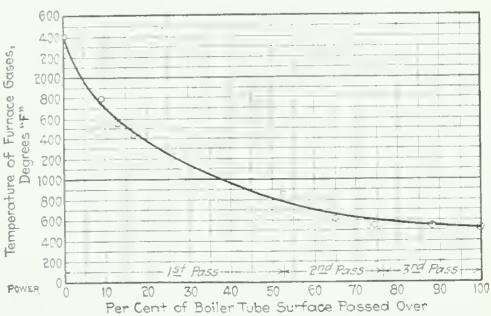


FIG. 1. CURVE OF TEMPERATURE VARIATION THROUGH A BOILER FURNACE

If the fourth pass be obtained simply by putting in more baffles in an existing boiler, that is reducing the surface in the first three passes to accommodate the fourth, it is doubtful whether the expected reduction in terminal temperatures will be realized, since there is no more boiler surface than before, and the only factor tending to a greater heat absorption is the increased velocity of the gases. On the other hand, greater draft will undoubtedly be required, since the intensity of draft required increases as the square of the velocity and as the amount of surface in the walls of the gas passages.

Fig. 1 shows temperature readings taken in a boiler of the B. & W. type, operated at about nominal capacity, that is, 10 sq.ft. to the boiler-horsepower, and fitted with three passes, the third and last pass containing some 23 per cent. of the total surface. If the thermometers are to be trusted the reduction in temperature in the third pass is only some 40°. I have figures relating to another boiler, and shown on the boiler outline Fig. 2, which, while not taken at so many different points in the path of the gases, agree fairly well with those given on the chart. As this second set of figures shows that the temperature at the end of the first pass was 800° F. and at the end of the third pass, 500°, about the same as in the first boiler; the distribution of the temperature between these two points probably coincided also. That a fourth pass would help in either boiler appears doubtful.

If the fourth pass is obtained by greater subdivision of the existing surface, the draft resistance will be increased considerably without a great increase in heat absorption, and, if we provide for the fourth pass by installing longer tubes and more surface per boiler horsepower, the question is: Will the extra surface repay its own upkeep charges? All information on the maintenance charges of boiler surface indicates that the answer should be "No".

Several authorities give 12 per cent. as the proper figure to be allowed for depreciation, repairs and upkeep on the boilers and equipment, and adding 5 per cent. for interest on the investment, the total charge comes to 17 per cent. The cost of boilers installed complete is rarely less than $2 per sq.ft., so that the annual charge on each square foot is 34c.

Assuming that the additional fourth pass is to reduce the flue gas temperature by 25 to 50° F., it will have to contain at least 2 sq.ft. of surface per boiler horsepower. (The low rate of absorption in the last pass, it might be mentioned, is due to the gases more nearly approaching the temperature of the water and steam within the boiler, so that the temperature head, to which the flow of heat from the gases to the water is directly proportional, is very low.) Two feet of surface at 34c. per ft. is 68c. per year annual charge. Granting that 2 per cent. of the coal will be recovered by these 2 ft. and assuming that 4 lb. of coal was originally

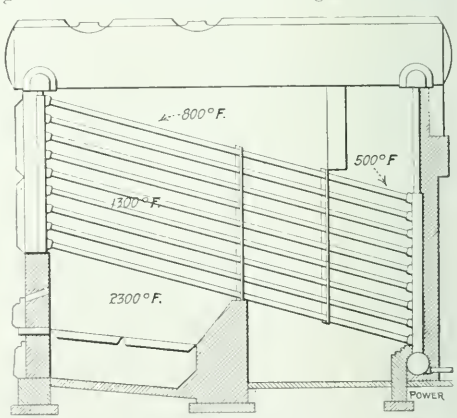


FIG. 2. TEMPERATURES FOUND AT POINTS INDICATED IN A WATER-TUBE BOILER

consumed per boiler horsepower-hour, and that the boiler is operated at full load for ten hours per day, 300 days per year, the coal saving, with $3 coal will amount to

$$\frac{4 \times 10 \times 300 \times 0.02 \times 3}{2000} = \$0.36$$

which is not enough to pay the annual charges upon the additional surface, not to mention the greater impediment to the draft, the greater difficulty of keeping the longer tubes tight and clean, the greater resistance offered to the circulation of the water through the tubes, etc.

The objection may be raised here that the deterioration of heating surface, in this last pass, subjected as it is to only moderate temperatures, will not be as great as in the rest of the boiler, but as the surface is in most boilers integral with those parts of the tubes exposed to the hottest gases, it will have to be discarded with them when they are burnt out and hence must bear the same charge for depreciation and repairs.

The editorial states that the increased draft through a four pass boiler will not, at the most, be greater than the draft necessary for a three-pass boiler with an economizer, which, taken with the remainder of the editorial, leads to the inference that the fourth pass is as good as, or to be preferred to, the economizer. Such, however, is far from correct, since an equivalent amount of economizer surface installed in place of the additional boiler surface would show much greater results, due to the lower temperature of its contents and consequently greater rate at which heat would be absorbed. If the temperature of the gases leaving the boiler is 500° F., and the temperature of the water and steam within the boiler is 370° F., a temperature head of only 130° is available. But pass the same gases through an economizer receiving water at 100° F., and a maximum temperature head of 400° is possible. In other words, per square foot, the economizer surface will recover three times as much heat, and since it costs less in the first place and does not deteriorate so rapidly, will pay more than three times the return. As a matter of fact, in installing an economizer it would not be good practice to stop with two square feet per boiler horsepower since satisfactory profits can be earned upon a much larger amount of surface. In the present example it would probably pay to reduce the temperature of the gases to 300° F., raising the temperature of the feed water to 200° F.

Furthermore, the most recent practice appears to be toward curtailing boiler surface, rather than increasing it, and many designers believe that it does not pay to install more than 4 to 6 sq. ft. per boiler horsepower output at maximum load. Under these conditions the gases will leave the boiler at 575 to 650° F. and the feed water will be delivered to the boiler from the economizer at upward of 250° F.

New York City. GEO. H. GIBSON.

Importance of Furnace Efficiency

In the article by Joseph Harrington, which appeared in the Dec. 17 issue of POWER, the argument was made that the heat balance from a boiler trial should be made on the basis of coal as fired. While computations based on coal as fired, including the moisture in the fuel would give the true efficiency of the boiler, furnace and grate for one particular case, the results could not be applied to compare the economy of a boiler with the same fuel but with different equipment; neither could the fuel under test be compared with other fuels. The amount of moisture in a fuel as fired depends to a considerable extent on conditions of transportation and storage which cannot be controlled. For the correct comparison of boiler trials the various economy and efficiency results should be based on the dry fuel as fired. Then, to represent the results under the conditions of the test as actually carried on, the economy and efficiency computations should also include results on coal as actually fired, including moisture.

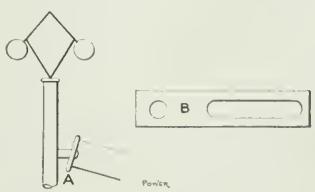
The boiler code of 1912 submitted by the Power Test Committee of the American Society of Mechanical Engineers gives the economy results in terms of the evaporation from and at 212 deg. F. per pound of wet coal fired, per pound of dry coal and per pound of combustible. These same comparisons should be carried out under the heading of efficiency and also the final heat balance should be based on wet coal as fired, on dry coal and on the combustible. The combustible is obtained by subtracting the ashes and other noncombustible matter in the coal, which passes through the grate or is removed during cleaning, from the dry coal.

A. A. POTTER.

Manhattan, Kan.

Equalizing Cutoff without Dashpot Troubles

In the Nov. 5 issue, E. P. Haines discusses the matter of equalizing the cutoff throughout the range of the governor. He tells how this was accomplished, but states that the trouble with the dashpots was not entirely overcome even with the special construction of the knockoff-cam-arms and the head-end hook lever. If Mr. Haines will turn to page 293, of the Feb. 9, 1909, issue of POWER,



he will find a very simple means for getting an equalization of cutoff without any annoyance whatever from dashpot trouble.

G. D. LIVINGSTON.

Minneapolis, Minn.

[The manner of equalizing the cutoff, referred to, as described in the letter in the Feb. 9, 1909, issue, is, essentially, as follos:

To get the crank-end valve to stay open longer at full load and close sooner at light load, the lower end A of the governor rocker-arm, operating the cam of the crank-end valve was made longer. To determine the proper length of the lower end of A, a piece of iron B, about ⅛x3¼x3 in., was drilled to be bolted to the arm. The slot was used to attach the governor reach-rod. By taking a diagram at a light load and one at a heavy load the necessary length was easily determined. A new rocker-arm was then cast, the lower end of which was made as long as the experiment indicated was necessary—Editor].

INQUIRIES OF GENERAL INTEREST

Boiler Walls—Should the walls of a boiler setting be hollow or solid?

W. E. T.

Recent tests by the Bureau of Mines indicate that there is no advantage in hollow over solid walls. The latter show less loss of furnace heat by convection than hollow walls.

Valve Slam—How can "valve slam" on the water end of a pump be prevented?

H. W. W.

By putting an air chamber on the suction pipe. If the intake water is received under pressure, the chamber should be put near the pump. If the water is taken from a well or cistern, a foot valve should be used on the suction pipe and the air chamber connected near the surface of the water.

Stopping Corliss Engines—What is the proper way to stop and start a high-speed Corliss engine? Should both the steam and exhaust-valve rods be unlatched?

G. F.

To stop a single Corliss engine, so that it will be off center when it comes to rest, it is advisable to unhook the wrist plate. If it is a double eccentric engine, it is usually only necessary to unhook the steam valve when stopping or starting.

Advantage of Smoke Flue Covering—What would be the atvantage of covering the flue and uptake of a boiler with 2 in. of asbestos?

F. G.

It would make the boiler room cooler and might increase the capacity of the stack. The best draft is with a chimney temperature of 620 deg. F., and, if the gases are now delivered to the stack at less than that temperature, the velocity of the chimney gases would be increased. If, as is more than likely, the stack temperature is already above 620 deg. F., there would be no advantage in the covering other than to make the boiler room cooler.

Pump Lifting Warm Water—If a plunger pump is placed close to its supply tank and 6 ft. above it, can it lift water at 150 deg. F.?

J. P. F.

Neither a plunger pump nor any other type can "lift" water under pressure of the atmosphere at 150 deg. F., a height of 6 ft., because the vapor given off by the water at that temperature when the pressure above it is reduced, destroys the vacuum created by the pump. Sufficient difference between the pressure of the atmosphere acting on the surface of the water in the tank and that in the suction pipe cannot be maintained to raise the water 6 ft.

Pump Horsepower—What horsepower is required to pump 210 gal. of water per minute against a pressure of 86.8 lb.?

N. K. F.

The water pumped per minute, 210 gal., is equal to

$$210 \times 231 = 48{,}510 \text{ cu.in.}$$

Pumping 12 cu.in. against 86.8 lb. per sq.in. pressure is doing 86.8 ft.-lb. of work. Therefore, pumping 48,510 cu.in. per min. against this pressure is a work of

$$\frac{48{,}510 \times 86.8}{12} = 350{,}889 \text{ ft.-lb. per min.,}$$

or,

$$\frac{350{,}889}{33{,}000} = 10.6 \text{ hp.}$$

Running Lap-jointed Belts—When a belt has a cemented lap joint, which way should the lap point with respect to its direction of motion?

H. N. Q.

Many prefer to put the end of the inside lap so that it travels toward the pulley, then any slip of the driving pulley would tend to wipe the joint down to position. However, if the driven pulley is the one inclined to slip, the lap should be run the opposite way. The same is true if the belt is where it is likely to be wet and the point of the lap become loose from the inside of the belt, as then it would be apt to be turned up or away from the belt as it strikes either pulley. Generally, the governing condition is which pulley is most inclined to slip and then the lap should be run in the direction that will tend to keep it laid against the belt.

Burning Wood and Coal—With which is there the least waste of combustible matter, in the burning of wood or coal?

J. D.

Ordinarily, there will be less waste of combustible matter when burning wood under a boiler, for, when burning coal, there is more chance that some of the combustible matter will not be reached by the heat of the fire. Recovery of the good fuel passing through the grates is easier with wood than with coal, as the unburned part is more easily separated from the ashes. With a proper regulation of the air supply, there can be as complete combustion with one fuel as with the other.

Safety Valve Size—What governs the proper size of a safety valve for a given boiler?

N. A.

This is determined by the grate area and the pressure to be carried on the boiler. A very good formula for safety valve size is:

$$A = \frac{37.5 \times G}{P}$$

where

A = Area of valve in sq.in.;
G = Area of grate in sq.ft.;
P = Absolute pressure in lb. per sq.in., or gage pressure plus 15 lb.

Compression Space in Pump—What amount of cushion space is required in a pump to prevent the piston striking at the end of the stroke?

W. H. W.

The proper cushion space will depend on the speed of the pump and the weight of the reciprocating parts. No rule can be laid down for calculating the compression space. It must be determined for every design and service of pump by experience. In some pumps, such as fire pumps, which are driven at a high piston speed, the compression can be regulated by adjusting the compression or cushion valves to permit more or less of the compressed steam to escape to the exhaust. The first item on page 672 of May 7, 1912, issue, illustrates the cushion valves of a pump cylinder and explains their function and action.

Testing Squareness of Engine Shaft—How can the shaft of a horizontal engine be tested to see that is square with the guides and the center line of the cylinder?

J. R. C.

Stretch a horizontal line (fish line is best) taut over the center of the guides and cylinder, making it fast to fixed supports at each end. Test it for exact position by dropping a plumb line beside it (always on the same side) and shift it until it is exactly parallel with the engine center line. Then stretch another horizontal line at right angles with the first and touching it, putting it as nearly as possible with the eye directly over the center of the shaft. To get the two lines perpendicular to one another, measure from their intersection 3 ft. along one line and 4 ft. along the other. Mark these two points by sticking needles through the lines. When the lines are at right angles, the distance between the needles will be exactly 5 ft. Any other multiples of these dimensions, 3, 4 and 5, as 30, 40 and 50, may be used, or any distances bearing the same ratio. When the two lines are at right angles, a plumb line dropped from the line over the shaft touching it (always on the same side) should hang the same distance from the center line of the shaft wherever it is dropped. If it does not, the outboard bearing should be shifted until it does.

ENGINEERS' STUDY COURSE

Mensuration—Part IV

Polygons

A *polygon* is a *plane figure* inclosed by any number of straight lines.

Thus triangles, rectangles, hexagons and octagons are examples of polygons. A polygon is said to be *regular* when all its sides and the angles formed by the sides are equal. A regular polygon is shown in Fig. 1. An *irregular* polygon is one whose sides or angles are not all

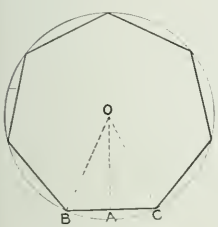


Fig. 1

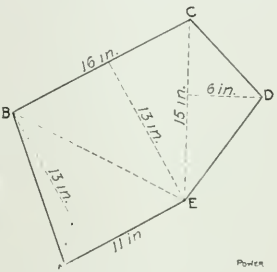


Fig. 2

equal. Such a polygon is shown in Fig. 2.

The *perimeter* of a figure is the total length of its sides or boundary.

At a glance we can see that it is much easier to measure the area of Fig. 1 than of Fig. 2, because all the angles in Fig. 1 are equal, and, having laid off the triangle *BCO* and found its area by multiplying *BAC* by one-half of *AO*, we simply multiply by the total number of triangles to get the area of the polygon. With the

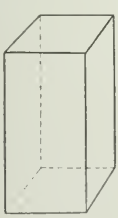


Fig. 3

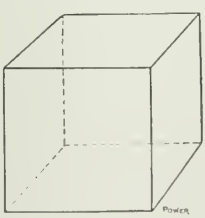


Fig. 4

irregular polygon, we must divide it into triangles, as was done in Fig. 2, before we can readily find the area. The student should always study closely an irregular polygon before laying off the triangles, as the aim is to make as few triangles as possible.

Let Fig. 2 represent a piece of sheet iron and let it be required to find the area.

We have three triangles, with the areas as follows:

Area *BAE* is

$$\frac{11 \times 13}{2} = \frac{143}{2} = 71.5 \ sq.in.$$

Area *EBC* is

$$\frac{16 \times 13}{2} = \frac{208}{2} = 104 \ sq.in.$$

Area *DCE* is

$$\frac{15 \times 6}{2} = \frac{90}{2} = 45 \ sq.in.$$

The total area of the polygon is

$$71.5 + 104 + 45 = 220.5 \ sq.in.$$

This method may be applied to any irregular polygon.

Suggestion: Find what it would cost to lay a concrete floor for an engine room, shaped as an irregular polygon. The cost of such flooring will average 25c. per sq.ft.

Prisms and Cylinders

A *prism* is a solid, whose bases are polygons and whose sides are parallelograms.

Prisms are of many kinds, i.e., they are rectangular, triangular, hexagonal, etc., according to the form of their

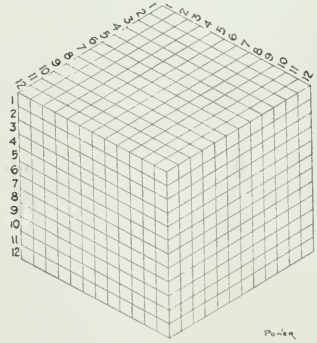


Fig. 5

bases. Many water and other kinds of tanks may be considered as prisms. Rectangular prisms are shown in Figs. 3 and 4. Fig. 4 is called a cube.

A *cylinder* is a body whose ends form parallel circles and which is of uniform diameter. A cylinder is not a prism.

Areas are figured in square measure, as square inches or square feet and volumes are figured in cubic measure, as cubic inches or cubic feet.

We learned in our lesson on denominate numbers, Nov. 26 issue, that a unit of volume such as the cubic inch, is the volume of a cube whose sides are 1 sq.in.

To illustrate this unit of volume, consider the cube, Fig. 5, the edges of which measure 12 in., the area of a side will be

$$Area = base \times altitude$$

or

$$12 \times 12 = 144 \ sq.in.$$

We see that the cube is divided into twelve slices, each slice containing 144 sq.in. As Fig. 5 has twelve such

slices, containing 144 sq.in. each, the whole cube, or cubic foot, contains

$$144 \times 12 = 1728 \ cu.in.$$

Thus, to reduce cubic inches to cubic feet, we divide by 1728 and to reduce cubic feet to cubic inches, we multiply by 1728.

From the above, we may form the rule for finding the volume of a prism or of rectangular vessels. The term *cubical contents* means the same as volume.

Rule: *Multiply the area of the base by the altitude.*

Example: How many gallons of water will a rectangular water tank 18 ft. long, 7 ft. high and 10 ft. wide contain? One U. S. gallon contains 231 cu.in.

The volume of the tank is

$$18 \times 10 \times 7 = 1260 \ cu.ft.$$

The number of gallons contained is

$$\frac{1260 \times 1728}{231} = 9425.45 \ gal.$$

Example: If there is a load of 1236 lb. on the supports holding the empty tank, what will be the load supported when the tank is full of water? Water weighs 8.33 lb. per gal. at 62 deg. F. The total load is

$$(9425.45 \times 8.33) + 1236 = 79,750 \ lb.$$

The *lateral area* of a prism is the total area of its sides or faces, except its ends or bases.

To find the lateral area.

Rule: *Multiply the perimeter of the base by the altitude.*

Example: We are to line the tank in the previous example, with zinc. Allowing 22 sq.ft. additional area for the overlap at the seams, how many square feet of zinc will we need?

The perimeter being

$$(18 + 10) \times 2 = 56 \ ft.$$

the lateral area is

$$56 \times 7 = 392 \ sq.ft.$$

Adding the area of the bottom

$$18 \times 10 = 180 \ sq.ft.$$

and the 22 sq.ft. for the seam laps, the total area of zinc needed is

$$392 + 180 + 22 = 594 \ sq.ft.$$

The *convex area* of a cylinder is equivalent to the area of the rectangle that would be formed by spreading out the side of the cylinder, as in Fig. 6, although in Fig. 6 only one-half of the side is shown spread out. We see,

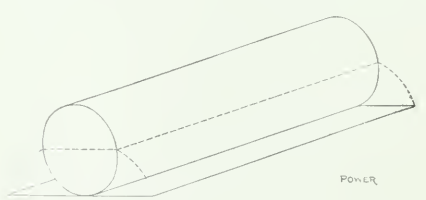


FIG. 6

from this, that the rule for finding the convex area of a cylinder will be

Rule: *Multiply the circumference by the altitude.*

Example: For surface condensers serving turbines, 3.5 sq.ft. of cooling surface is sometimes allowed per kilowatt. According to this rating, what capacity turbo-generator could be served by a surface condenser having 7020 tubes 14 ft. by 0.75 in.?

The circumference of one tube is

$$0.75 \times 3.1416 = 2.36 \ in.$$

The convex area of one tube is

$$14 \times 12 \times 2.36 = 396.48 \ sq.in., \text{ or } 2.75 + sq.ft.$$

The capacity of the condenser would be

$$\frac{7020 \times 2.75}{3.5} = 5515.6 \ kw.$$

Example: At a steam consumption of 12.8 lb. per kw.-hr. for the turbine, how many pounds of steam would the condenser handle per hour?

$$5515.6 \times 12.8 = 70,609.68 \ lb. \quad \text{Ans.}$$

EXAMPLES FOR PRACTICE

(1) (a) How many gallons of water will be contained in a water-works standpipe 18 ft. in diameter by 125 ft. high?

(b) Making no allowances for losses, in what time will the standpipe be filled by a duplex pump having 30-in. plungers, 34-in. stroke, each of the two plungers making 18 strokes per minute?

A rule sometimes given for finding the water capacity of a return-tubular boiler is:

Find ⅔ the volume of the shell and from this subtract the volume of all the tubes.

(2) Example: What is the water capacity in cubic inches of a boiler 18 ft. by 72 in. with 72 three-inch tubes?

(a) Capacity in gallons?

(b) Capacity in pounds?

Due to an error in pointing off the number of decimal places in the example (Feb. 4 issue) for finding the area of a safety valve, by the Massachusetts formula, an answer of 2½ in. instead of 3.77 in. was obtained for the diameter of the valve.

As applicants for engineers' licenses are usually called upon to work out this formula, the example given in the Feb. 4 issue is fully worked out below.

Massachusetts safety-valve area formula:

$$A = \frac{W \times 70 \times 11}{P}$$

A = Area of valve in square inches for each square foot of grate surface;

W = Pounds of water evaporated per second per square foot of grate surface;

P = Absolute pressure per square inches at which valve is to open.

Example: A boiler has 30 sq.ft. of grate surface, a combustion rate of 20 lb. of coal per square foot of grate per hour, evaporation of 10 lb. water per pound of coal; gage pressure 100 lb. What size safety valve is required?

$$30 \times 20 = 600 \ lb.$$

coal burned per hour.

$$600 \times 10 = 6000 \ lb.$$

water evaporated per hour.

$$\frac{6000}{3600} = 1.67 \ lb.$$

water evaporated per second.

$$1.67 \div 30 = 0.05567 \ lb.$$

water evaporated per square foot of grate per second.

Substituting, we have,

$$A = \frac{0.05567 \times 70 \times 11}{115} = 0.3728 \ sq.in.$$

area of valve for one square foot of grate.

As there are 30 sq.ft. of grate, the area of the valve will be:

$$0.3728 \times 30 = 11.184 \text{ sq.in.}$$

The diameter of a valve of 11.184 sq.in. area, will be

$$\sqrt{\frac{11.184}{0.7854}} = 3.77 \text{ in.}$$

A 4-in. valve would be the proper size valve to install.

Boiler Capacity Required to Heat a Swimming Pool

By J. P. Lisk

As a general rule the operating engineer of a power plant is not interested in the design of swimming pools, but he is interested in the boiler power it requires to heat one up ready for use, if it so happens that he has such a heat consumer attached to his plant. Heating the water in the pool from 40 to 80 deg. F. is the average requirement in practice, and the time taken varies from four to eight hours, depending on local conditions.

A boiler horsepower is equivalent to the evaporation of 34.5 lb. of water from a feed-water temperature of 212 deg. F. into dry steam of the same temperature. A British thermal unit is the quantity of heat required to raise the temperature of one pound of water one degree at its greatest density. These units were used in determining the constants in the following rules for finding the boiler horsepower required in any case in which the rise in temperature is 40 deg.

When the quantity of water in the pool is given in pounds, multiply by 0.0012.

When in gallons, multiply by 0.01.

When in cubic feet, multiply by 0.075.

In each case divide by the number of hours in which the work is to be done.

When the rise in temperature is more or less than 40 deg., the formulas given below may be used.

$$Hp. = \frac{(t_2 - t) \times h \times P}{U \times T} \quad (1)$$

$$Hp. = \frac{(t_2 - t) \times h \times a \times G}{U \times T} \quad (2)$$

$$Hp. = \frac{(t_2 - t) \times h \times b \times C}{U \times T} \quad (3)$$

t = Initial temperature of water;
t_2 = Final temperature of water;
h = Quantity of heat to raise one pound of water one degree in temperature = 1 B.t.u.;
U = Units of heat in one boiler horsepower = 33,479;
$Hp.$ = Boiler horsepower to do the required work;
T = Time in hours in which the work is to be done;
P = Weight of water in pounds;
G = Quantity of water in gallons;
C = Quantity of water in cubic feet;
a = Pounds in gallon of water = 8.335;
b = Pounds in cubic foot of water = 62.35.

Formula (1) is to be used when the quantity of water is given in pounds, formula (2) when in gallons and formula (3) when the quantity is expressed in cubic feet.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Out on the Pacific Coast the engineering folks are much perturbed over what they call the "Hetch Hetchy" project. Just what is this project, and why the perturbation? We've heard of the hootchee-kootchee, read of the hari-kari and fraternized with the hunyadi, but somebody must put us hep to this hetch hetchy thing. Anything like beri-beri or tummyache?

Apropos of ailments, the Civic Federation wise guys say we of the laboring classes are physically going into the discard if we don't watch out. There's boiler maker's deafness, hatter's shakes, potter's rot, painter's colic and wrist-drop, caisson worker's bends, match maker's phossy-jaw, brass worker's chills, glass blower's cataract and miner's asthma. Phew! We're some ailing. Skipping the hookworm, who overlooked the blind staggers, the botts and the housemaid's knee?

Sydney Pickles (real name) has pulled the heinz over all the other well known varieties by "reaching a height of 7200 ft. in his airship." No, Eustace, there was nothing the matter with Pickles' feet as he was walking down the street. When you saw Syd, he was bound for the hangar—you know, the stable where they tie up an airship and bed it down.

Mr. Livergood has resigned as chief engineer for the Central Illinois Public Service Co.—"Electric Railway Journal." Now, don't get personal. We are just turning the lights on Mr. Livergood, as he is going into the electrical business for himself. May he live a good long life, and prosper.

This is "old home" week with our engineering humorists, and proves that your Uncle Spill is not all there is to a jingling jest and joyous jumble. We have with us this evening, Brother Pattison, of Lexington, Ohio, who will say a few words:

Hex Nut—How's the old head, Cy Linder? Where were you yesterday?

Cy—I went to the races. I saw the Engine race and the Mill race, but best of all was the Run of the Mine. Anthracite Coal was coming up hard when she leaped out of the shafts and landed in a heap on the track. They took An out to crush'er and she's been nutty ever since. An's brother Bi was also entered, but he was too soft—just in from the fields. A peculiar thing about Bi is that when given the rain he slacks up. Bi got away with the big lump, though, and you ought to have heard them roast him in the Coke Oven event. Bi thinks that smoking should not be allowed in a furnace, bue he stacked up pretty well there except when the Boiler flew. After the final heat, everybody said that Bi was the best that ever hit the dump.

Here's one, I see, from Tennessee. Lloyd V. Beets raised it in his garden and sends it to market:

A certain salesman was noted for his habit of occasionally taking a week "off" when the Tennessee mountain dew got within his midst.

Finally, his boss lost patience and wrote: "I've preached, sworn and prayed that you would take an interest in this firm. What do you intend to do?"

The quick-witted and dew-wetted salesman sent this telegram: "I'll take an interest. Don't change name of firm until I return.

Here's a tale of a soft corn that is hard to believe, from Framingham, Mass.

Taddy, the long, lean assistant engineer at the power house, had a corn on his toe so tender that when on duty he had a shoe and a stocking especially cut to keep down its temperature within comfortable bounds. He was just as sensitive as the corn was about it. The other day he was putting in a new carbon on the live side of a circuit-breaker. He stood on a chair, and the corn protruded over the edge in dangerous proximity to the main switch. I was about to warn him when he moved. There was a flash and a yell, and Taddy lay stunned on the floor. Now, he wears a whole shoe and that particular corn bothers him no more. Wonderful, what electricity accomplishes these days, ain't it?

Large High Vacuum Condenser Test

By J. J. Brown

SYNOPSIS—Data pertaining to a test of a large high vacuum condenser which was guaranteed to produce as high as 28.9 in. of vacuum with 70 deg. cooling water. The test shows that this guarantee was exceeded. Charts and tables and details of the test are given.

The test figures and curves given herewith, demonstrate the success that has been achieved in solving the problem of high-vacuum condenser design.

Vacuums from 28.3 to 28.9 in. were guaranteed with 70 deg. inlet cooling water. The small margin between these vacuums and the maximum attainable can hardly be realized without citing a few figures from the steam table. If the cooling water were to be heated only one degree in the condenser (that is, from 70 to 71 deg.), then the maximum vacuum obtainable would be 29.23 in. If it were heated to 80 deg., the maximum vacuum obtainable would be 28.97 in.; if heated to 90 deg. 28.58-in. the vacuum would be the maximum.

It is evident, therefore, that the task imposed upon the condenser designer by the demands for high vacuum with steam turbines, has been a severe one. The surface must transmit heat at very high efficiency because the available temperature difference or "heat head" causing the flow of heat is but a few degrees. The air and noncondensible gases are at an even lower pressure than that of the turbine exhaust and the greatest refinement must be observed in the manufacture of the air pump, in order that it may successfully withdraw these highly rarified gases from the condenser.

There are many other very interesting phases of the problem of high-vacuum condenser design, as, for instance, the proper arrangement of dry plates to prevent flooding of the tube surface with condensate or "steam water" and to maintain high temperature of condensate; the arrangement of tube surface to give high velocity of water through the tubes; the design of the circulating pump and circulating system so as to cause the least consumption of power in pumping the cooling water; and finally, the arrangement of tube surface to give efficient steam distribution.

At high vacuums, the specific volume of steam becomes enormous and the addition of tube surface to a condenser of ordinary design, may entirely defeat the purpose of the designer because of the increased resistance to the flow of steam between the tubes.

The loss of head through an orifice varies as the square of the velocity and as the first power of the density. For a constant weight of steam per second, corresponding to a constant turbine load, the resistance varies directly as the square of the volume and inversely as the first power of the volume. In other words, the resistance varies directly as the first power of the volume. The increase in volume with increase in vacuum, is indicated by the following figures:

Vacuum	Specific Volume*
26	176.7
27	231.9
28	339.6
29	657.0
29.5	1259.0

*"Steam Tables for Condenser Work," published by Wheeler Condenser & Engineering Co.

At a 29-in. vacuum the resistance flow is almost four times the resistance at 26 in.

Furthermore, an increase in vacuum means lower rate of condensation per square foot of surface. Accordingly with an increase in vacuum there is less condensation on the first rows, and a greater weight of steam must flow through the restricted area between the tubes at the top of the condenser. This additional flow causes increased resistance and back pressure, or lower vacuum.

An attempt to obtain better vacuum by the addition of tubes may thus be entirely unsuccessful, unless provision has been made for efficient distribution of the steam to all of the tube surface without undue resistance and back pressure.

These considerations lead to a very flat condenser of small height, covering a very large area. But such a design requires too much floor space and has an added drawback in that the noncondensible gases are spread throughout the lower region of the condenser in a sheet of large area, whereas for efficient removal, the air should be concentrated at a few points. The advantages of the large, flat condenser without its disadvantages, are secured by the use of the rectangular shell and the proper arrangement of tubes and baffles.

Tubes from various portions of the top of the condenser are omitted, thus providing passageways to conduct the steam to a number of short banks of tubes and insuring its penetration to all of the surface. Distribution of the steam to the surface in this manner also prevents dead air spots, since the various banks of tubes are short and the circulation is vigorous and positive. The air is swept on to the lower part of the condenser where it passes over tubes arranged to cause brisk circulation of the steam-air mixture, so that when it enters the air-pump suction, the steam vapor has been removed to a large extent, and the mixture is rich in air. To further increase the density of the air, and to remove the water vapor, independent air coolers are sometimes installed, especially in large installations of the kind to be described.

Condensing Equipment Tested

This condenser is of the dry-tube base design, manufactured by the Wheeler Condenser & Engineering Co., Carteret, N. J., and is installed at the south works of the Illinois Steel Co., South Chicago, Ill., in connection with a 7000-kw. Curtis mixed-pressure turbo-generator. Fig. 1 shows the arrangement of turbine, base condenser and condenser auxiliaries in plan and elevation. Fig. 2 shows the turbo-generator, Fig. 3 the centrifugal circulating pump and Fig. 4 the rotative dry-vacuum pump.

Low-pressure steam goes to the turbine from three 2000-kw. compound, reciprocating engines, which discharge into a header about 100 ft. long. The steam enters the turbine at a few pounds above atmosphere, having passed through a large separator (shown behind the air pump in Fig. 4), which is designed to remove all but a small percentage of the moisture. In addition to this supply of steam, the exhaust from blast-furnace blowing engines and auxiliaries is used up to a total turbine

capacity of 200,000 to 250,000 lb. per hour. High-pressure steam to carry the load in case of a deficiency in the supply of exhaust steam, is obtained from the boiler plant, the piping being seen above and to the right of the turbo-generator in Fig. 2.

The turbine rests upon the condenser as a base. The tube surface is arranged in two sets of banks on either side of the center line with dry plates at several elevations on each side of the center which drain outward toward the shell. They divide the tube surface into a number of compartments, designed to give the most efficient and even distribution of the steam to all of the surface.

There are about 6000 tubes of 1-in. diameter, making in all about 25,000 sq.ft. of surface. The circulating water makes two passes through the tubes, entering at one end and passing through the lower bank of tubes on both sides of the center, returning through the top bank to the discharge.

The circulating system is closed, the water being drawn from Lake Michigan through an intake tunnel 150 ft. long and discharged to a sewer. The head on the circulating pump is from 10 to 20 ft., and the quantity of water pumped is from 24,000 to 34,000 gal. per min. Of this head, about half is lost in the condenser. (See test curves in Fig. 5.) The circulating pump is a Wheeler 36-in. double-suction volute pump, operating at a speed of from 100 to 135 r.p.m. driven by a 20x24-in. Cooper Corliss engine, seen in the background of Fig. 3.

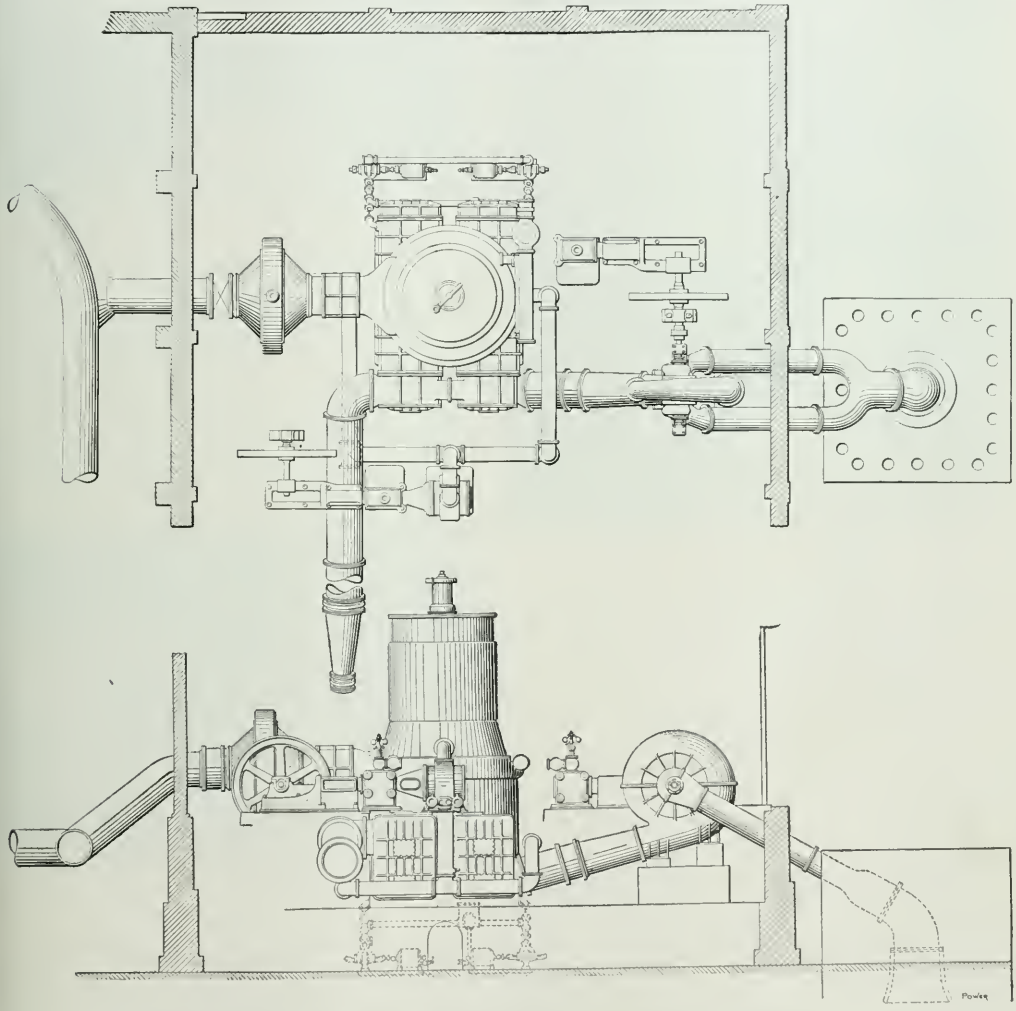


FIG. 1. PLAN AND ELEVATION OF THE TURBINE AND CONDENSER UNIT

The 11 and 36 by 24-in. Wheeler tandem rotative, dry-air vacuum pump has shown remarkable efficiency, as indicated by the tests of Table 1. The air is withdrawn near the bottom of each side of the base condenser by two air pipes running horizontally and joining opposite the

end of the condenser where they meet a pipe which rises through the engine floor, making a vertical loop before connecting to the pump. Within the vertical riser is a specially designed air cooler.

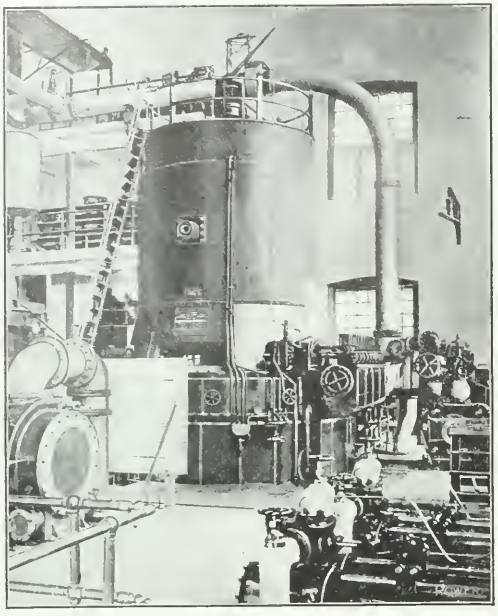


FIG. 2. 7000-KW. CURTIS TURBO-GENERATOR

Two 5-in. centrifugal hotwell pumps are installed, driven by 24-hp. steam turbins.

GUARANTEED PERFORMANCE AND RESULTS OF TEST

The guarantees made on the condensing equipment were as follows:

Temperature of cooling water 70 deg. F.

Quantity of water, not more than 34,000 gal. per min.

Vacuum	Load in lbs. of Steam per Hour
28 3	210,000
28 5	185,000
28 6	150,000
28 7	120,000
28 9	70,000

A summary of the tests made by the steam-engineering department of the Illinois Steel Co., to check the guaranteed values, is given by Table 2. The tests were made in July, 1910, with inlet circulating water at 73.4 to 73.7 deg. F. In calculating the final results, the performance was corrected to 70 deg. water, and a smooth

TABLE No. 1. TEST OF WHEELER R.D.V. PUMP. ILLINOIS STEEL COMPANY—JULY, 1910.

		Steam Cylinder		Air Cylinder		
Time	Speed	M.E.P.	I.H.P.	M.E.P.	I.H.P.	Mech. Eff.
3:21	81	32 8	61.9	5 40	53 7	86.8
3:26	93	35 0	75 6	5 55	63 3	83 5
3:30	93	34 15	74 0	5 25	60.0	81.1
3:35	94	32 5	71.1	5 37	62 0	87 1
3:40	93	34 0	73 6	5 43	62 0	84 2
3:45	94	33 7	73 8	5 36	61 8	83 7
3:50	94	33 5	73 3	5 48	63 2	86 2
3:55	93	34 25	74.2	5 46	62 4	84 0
4:00	93	34 5	74 7	5 33	60 9	81 5
4:05	94	33 25	72 8	5 55	64 0	88 0
4:10	93	34 0	73 8	5 36	61 2	83 0
4:15	94	33 0	76 6	5 36	61 8	80 7
4:20	94	34 5	75 5	5 43	62 6	83 0
4 25	93	34 0	73 6	5 36	61 2	83 2
4:30	94	34 1	74 6	5 31	61 2	82 0
4:35	93	33 35	72 2	5 25	60 0	83 1
4:40	93	33 35	72 2	5 37	61 3	84 9
4:45	93	34 4	74 3	5 33	60 8	81 7
4:50	94	34 35	73.0	5 40	62.3	85 3
4:55	93 5	32 5	70 6	5.36	61 5	86 9
5:00	94	33 45	73 2	5.28	60 9	85 2
5:05	94	34 1	74 6	5.22	60.2	80 7
5:10	94	32 7	71.6	5.19	59.8	83 5
Average	93 0	33.76	73.1	5.37	61.2	83.89

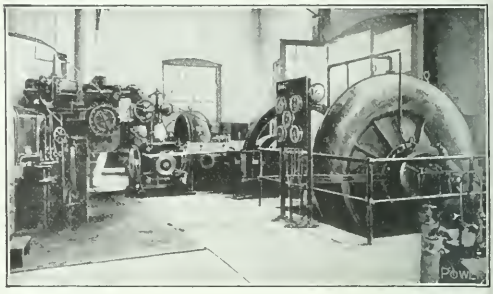


FIG. 3. CENTRIFUGAL OSCILLATING PUMPS

curve drawn between vacuum and load is given in the chart of Fig. 6. The same chart also gives the actual vacuums with the water averaging about 73.6 deg. F.

According to readings taken at the time of the condenser tests, the quantity of water was slightly under 35,000 gal. per min., and in calculating the vacuum, correction was made to 34,000 gal. per min. capacity, as the guarantees were made upon this basis. It should be stated here, however, that subsequent investigation led to the discovery of an error in the meter for measuring the circulating water, so that the actual quantity pumped

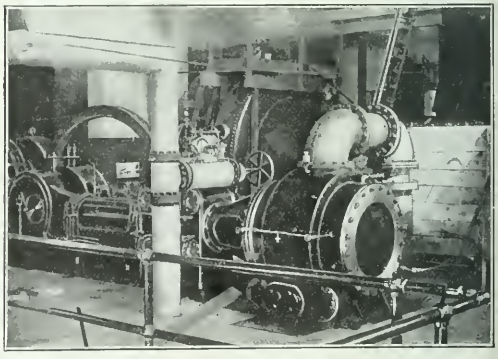


FIG. 4. ROTATIVE DRY-AIR PUMP

was somewhat less than 34,000 gal. per min., instead of more. When the apparent heat absorbed by the circulating water (taken in pounds per hour and temperature rise) was checked against the heat given up to the water by the steam condensed, an error was found which verified the foregoing. The corrections applied to the observed vacuum are, therefore, far from partial.

In Table 2, summarizing the tests, the following items should be noted: The remarkably high vacuums obtained with cooling water at 73½ deg. temperature; the small difference in temperature between the discharged condensing water and the steam, that is, from 4 to 10 deg.; the high hotwell temperature, ranging only from 2 to 6 deg. below steam temperature, and the high coefficient of heat transmission: 550 B.t.u. per sq.ft. per hour per

degree difference in temperature with a load of 210,000 lb. of steam per hour.

The greatest load on the condenser was 210,000 lb. of steam per hour, but it is evident from the test that a load of 250,000 lb. of steam per hour would have been

TABLE NO. 2. TEST OF WHEELER DRY TUBE SURFACE CONDENSER. ILLINOIS STEEL COMPANY — JULY, 1910.

Average vacuum referred to 30" barometer	Temp. corresponding to vac.	Lb. steam per hr.	Hotwell temp.	Temp. inlet circ. water	Temp. outlet circ. water	Rise in temp. of circ. water	Coeff. of heat trans. B.t.u. per h. per sq.ft. per deg.diff. (Based on 980 B.t.u. per lb of condensate)
28 246	96 9	196,000	90.6	73 40	86 1	12 70	470
28 250	96.8	187,000	90.5	73 40	85.5	12 1	440
28 310	95.7	167,000	89 4	73 40	84 4	11 0	403
28 394	94.05	169,000	88 7	73 40	84 6	11.2	462
28 374	94.50	171,000	88 8	73 40	85.2	11 8	466
28 331	95.30	190 000	89 4	73.40	85 8	12 4	500
28 304	95.80	197,000	89 8	73.40	86 2	12 8	509
28 290	96.08	204,000	90.1	73 40	86 6	13.2	528
28 286	96 15	210,000	90.3	73.40	86 9	13.5	550
28 311	95 70	190,000	89 3	73.40	85 5	12 1	480
28 380	94.32	187,000	89 2	73.40	85 4	12.0	519
28 361	94 75	190,000	89 4	73.40	85 8	12·4	522
28 413	93.05	175,000	89 1	73.40	84.2	10.8	504
28 473	92 50	171,000	87 7	73 50	84 6	11 1	532
28 501	91.85	167,000	86 2	73 70	84.1	10 4	535
28 510	91 70	163,000	87 5	73 70	84 0	10.3	526
28 551	90.75	157,000	87 8	73 70	83 0	9.3	521
28 590	89.80	148,000	86 2	73 70	82 8	9 1	527
28 595	89 70	130,000	87 7	73 60	81.5	7 9	435
28 678	87 80	121,000	85 2	73 60	81 5	7 9	487
28 748	86.05	93,000	84 8	73 50	79 5	6 0	395
28 748	86.05	98,000	83 7	73.50	80 5	7 0	447
28 786	84.90	98,000	83 7	73 60	80 1	6 5	500
28 803	84.70	91,000	83 3	73 60	80.0	6 4	478

readily carried with 28-in. vacuum and 70-deg. water. This is equivalent to 10 lb. of steam per sq.ft. of surface, and under these conditions, the coefficient of heat transmission would have been about 600.

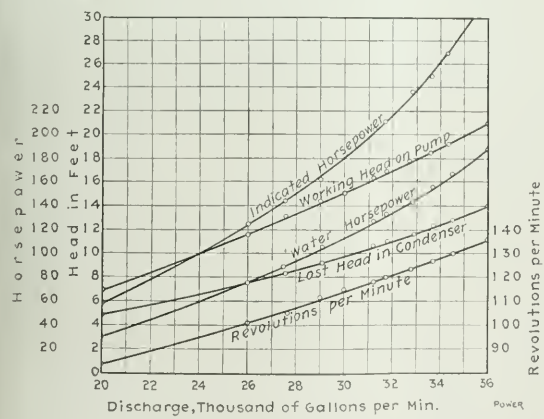


FIG. 5. SHOWING LOSS OF HEAD

The coefficients of heat transmission are calculated on the basis of 980 B.t.u. per pound of condensate, and by the logarithmic formula for heat transmission, which follows:

U = Coefficient of transmission in B.t.u. per hour per sq.ft. per degree difference in temperature;

W = Pounds of condensate per hour;

980 = B.t.u. per lb. of exhaust steam;

S = Square feet of condenser surface;

D = Mean temperature difference calculated by the following formula:

$$U = \frac{W \times 980}{S \times D}$$

Where

$$D = \frac{t_2 - t_1}{log.e \dfrac{t_s - t_1}{t_s - t_2}}$$

in which

t_s = Steam temperature corresponding to the vacuum;

t_1 = Inlet condensing water temperature;

t_2 = Outlet condensing water temperature;

$log.e$ = Natural logarithm.

It will be of interest to compare the heat transmission obtained in this condenser under actual operating conditions, with the heat transmission obtained in tests on experimental apparatus. The average water velocity in these tests was about 4.7 ft. per sec. Referring to the *Transactions* of the A. S. M. E., December, 1910, and the experiments by George A. Orrok on a condenser containing one tube, we find that for a circulating-water velocity of 4.7 ft. per sec., the coefficient of heat transmission as given by him is about 660 B.t.u. per sq.ft. per degree difference in temperature per hour. This coefficient is but slightly higher than the coefficient 550 obtained above.

TEST ON AIR PUMP AND CIRCULATING PUMP

In the test on the dry-vacuum pump, Table 1, attention is drawn to the average steam and air cylinder indicated horsepower and to the remarkably high mechanical efficiency.

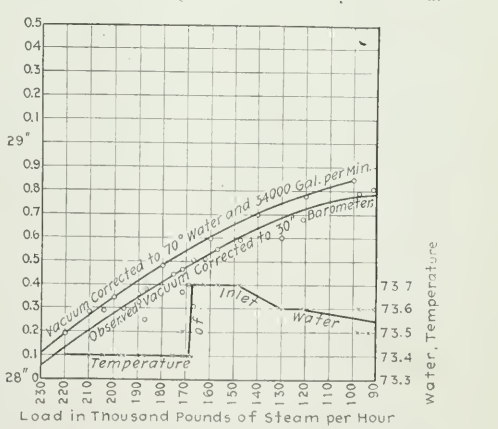

Vacuum, Inches
Revolutions per Minute
Vacuum Corrected to 70° Water and 54000 Gal. per Min.
Observed Vacuum Corrected to 30" Barometer
Inlet Water Temperature
Water Temperature
Load in Thousand Pounds of Steam per Hour

FIG. 6. VACUUM OBTAINED WITH WATER AVERAGING 73.6 DEG. F.

A test on the centrifugal circulating pump is covered by the charts of Figs. 5 and 7. By plotting the curve of head lost in the condenser against the discharge in gallons per minute on logarithmic paper, it is found that the head lost varies as the $1^{3}/_{4}$ power of the discharge; but since the velocity varies directly as the quantity of the water, we conclude that the head lost varies according to the 1.75 power of the velocity. This exponent is but slightly lower than the exponent 1.87 given in the American Civil Engineers' handbook, or than that

of 2, the exponent generally conceded as an average value. The exponent of 2 was checked several years ago by Prof. Josse and was found consistent with results obtained with a 300-kw. condenser.

As the water horsepower depends upon the quantity

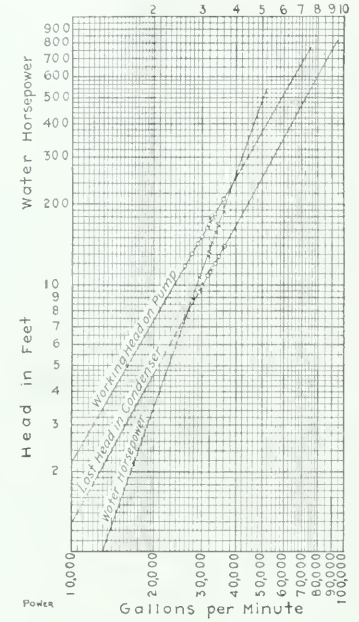


FIG. 7. CURVES OF CENTRIFUGAL-PUMP TEST

times the head, the horsepower should vary as the cube of the velocity. It is found by plotting the water horsepower curve of Fig. 6 on logarithmic paper (Fig. 7) that the exponent is 2.9; that is, the horsepower varies as the 2.9 power of the gallon per minute, or of the velocity through the condenser tubes.

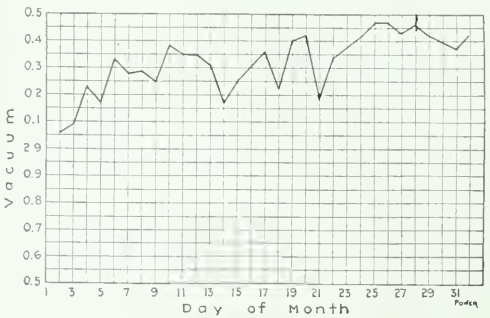


FIG. 8. LOG OF MONTHLY PERFORMANCE

A log of a month's performance of this condensing outfit is shown graphically by the chart of Fig. 8. This log covers performance in the month of January with the inlet cooling water down to about 34 deg. F. The performance is markedly consistent. The maintenance of vacuums of 29.3 in. and 29.4 in., day in and day out is what produces substantial savings in coal consumption.

Vitribestos Stack Lining

The smoke-stack of the First National Bank Bldg., Pittsburgh, Penn., which is 400 ft. high, is lined throughout with vitrified asbestos or "Vitribestos" to a thickness of 2 in. and presents a solid interior surface. It serves the double purpose of protecting the metal stack from sulphurous and other destructive acids and insulating it from great heat. These slabs of vitribestos, 3 ft. by 6 ft. and 2 in. thick, weigh, with all attachments, only 30 lb. per cu.ft. in place, or about 5 lb. per sq.ft. of stack area.

This building was designed to be 26 stories high, but only five stories were built in the original undertaking completed four years ago, and the original stack was lined as stated. When the remaining stories were completed, the stack was extended in 18-ft. sections, riveting all joints except at the ends of the sections, which were flanged joints. The 18-ft. sections were lined with Vitribestos before they were carried to the building, and were hoisted and set in place without interferring with the operation of the stack. When the last section was in place, the stack was lined, except at the open joints, every 18 ft.

With the arrival of mild spring weather, these joints were sealed up and inspection showed that the material which had been in service for four years was in as good condition as when first applied.

This vitribestos is manufactured by the H. W. Johns-Manville Co., of New York City.

BOOKS RECEIVED

THE "MECHANICAL WORLD" ELECTRICAL POCKET BOOK FOR 1913. Emmott & Co., Manchester, England. Cloth; 311 pages, 4x6 in.; illustrated; tables. Price, sixpence.

THE INDICATOR HANDBOOK. Part II. By Chas. N. Pickworth. Emmott & Co., Manchester, England. Cloth; 139 pages, 4¾x7¼ in.; illustrated; tables; indexed. Price, three shillings.

STEAM BOILERS. By E. M. Shealy. McGraw-Hill Book Co., New York. Cloth; 356 pages, 6x9½ in.; 185 illustrations; tables; indexed. Price, $2.50.

THE ELEMENTS OF HEATING AND VENTILATION. By Arthur M. Greene, Jr. John Wiley & Sons, New York. Cloth; 324 pages, 223 illustrations; tables; indexed. Price, $2.50.

TEXTBOOKS OF SCIENCE—The Elements of Machine Design. Part II. New and revised edition. By W. Cawthorne Unwin and A. L. McHanby. Longmans, Green & Co., New York. Cloth; 428 pages, 5½x9 in.; 311 illustrations; indexed. Price, $2.50.

PRACTICAL MATHEMATICS. Part III. By Claude Irwin Palmer. McGraw-Hill Book Co., New York. Cloth; 178 pages, 4½x7 in.; 31 illustrations; indexed. Price, 75c.

WINDING ENGINES AND WINDING APPLIANCES. By George McCulloch and T. Campbell Futers. Longmans, Green & Co., New York. Cloth; 452 pages, 5½x9-in.; 175 illustrations; tables; indexed. Price $6.

WATER, ITS PURIFICATION AND USE IN THE INDUSTRIES. By W. W. Christie. D. Van Nostrand Co., New York. Cloth; 219 pages, 5¼x8-in.; 79 illustrations; tables; indexed. Price $2.

ESSENTIALS OF ELECTRICITY. By W. H. Timbie. Wiley & Sons, New York, and Chapman & Hall, Ltd., London. Cloth; 271 pages; 7⅛x4⅝ in.; illustrated; tables; indexed. Price, $1.25.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION, WASHINGTON. Government Printing Office, Washington, D. C. Cloth; 688 pages; 9¼x6 in.; illustrated; tables; indexed.

AMERICAN WATER WORKS ASSOCIATION PROCEEDINGS, 1912. By the Association. Waverley Press. Cloth; 465 pages, 9¼x6½ in.; illustrated; tables; indexed.

ELEMENTS OF HEAT-POWER ENGINEERING. By Hirshfeld and Barnard. Wiley & Sons. Cloth; 811 pages, 9⅝x6¼ in.; illustrated; tables; indexed. Price, $5.

HANDBOOK OF ENGLISH FOR ENGINEERS. By Wilbur Owen Sypherd. Scott, Forsman & Co., Chicago and New York. Leather; 314 pages, 7x4¾ in.; indexed. Price, $1.50.

NEW PUBLICATIONS

STEAM ECONOMY IN THE SUGAR FACTORY. By Karl Abraham. Translated from the German edition by E. J. Bayle. John Wiley & Sons, New York City. Cloth; 104 pages, 5¼x7¾ in.; 15 tables. Price, $1.50.

The author, who is general engineer of the American Beet Sugar Co., translated the present book so that the American manufacturer might have the advantage of European practice concerning the proper distribution and management of steam to effect economies in the production of sugar from beets. Under a division heading of the Steam Consumption of the Individual Stations the author discusses diffusion, heaters, saturation of thin juice, steam consumption for heating the juice and for the evaporation proper, boiling, heating of the thick juice and syrups, treatment of the green syrups and the remelted products, turbinating and washing, steam losses due to radiation, and mechanical work. The second division of the book deals with the distribution of steam in the factory, covering methods of reduction of steam consumption, adaptability of different systems for utilizing juice vapors, distribution of temperature in the evaporating system, diagrams for the distribution of steam, influence of methods of operation on total steam consumption, calculation of heating surfaces. To help toward a better understanding of the text matter numerous problems are presented and the solutions given, and data and tables have been converted into English standards. The book should prove of value to engineers and designers of sugar plants.

MACHINE DESIGN—HOISTS, DERRICKS, CRANES. By H. D. Hess. J. B. Lippincott Co., Philadelphia. Cloth; 368 pages, 6x9½ in.; 318 illustrations and 18 plates; tables. Price, $5 net.

This book, although primarily intended to aid technical students in the work of machine design, should prove useful to anyone directly engaged in the design or manufacture of this class of machinery. The book is divided into twelve parts: Introduction, Frames and Girders, Brakes and Clutches, Winches and Hoists, Pillar Cranes, Jib Cranes, Under-braced Jib Crane, Inverted Post Crane, Wall Crane, Overhead Electric Traveling Cranes, Hoisting Engines, Locomotive Cranes.

The introduction includes a discussion of properties of materials and fiber stresses, the design of machine elements such as springs, belts, pulleys, gearing, shafting, bearings, chains, drums, crane hooks, etc.; elements of graphic statics, rolling and sliding friction, crane blocks, wire ropes, structural members and rivets.

In the other chapters suitable data are selected and the problems worked out, the illustrations being drawn from present-day American practice. The part devoted to electric traveling cranes is especially good. The treatment is simple and by applying elementary principles in determining the stresses in frames and machinery it is shown that the design may be carried out on a theoretical rather than on an empirical basis. The method of procedure in applying the principles of design to practice is clearly outlined, so that the book should be of great assistance in directing the student and serve as a valuable reference to the designer.

THE GAS ENGINE. By Hans Holzwarth, Engineer. Translated by A. P. Chalkley, B. Sc., Am. Inst. C. E., A. I. E. E.; 6x9 in.; 40 pages, illustrated, cloth. Charles Griffin & Co., Ltd., London. J. B. Lippincott Co., Philadelphia, 1912. Price, $2.50.

In our issue of February 6 last we described at considerable length a 1000-horsepower gas turbine, designed by Hans Holzwarth and built by Brown, Boveri & Co., at Mannheim. In this article we referred to a book recently published in German by Mr. Holzwarth which furnished largely the information upon which our article was based. The translation under review makes this work available in its entirety to English-speaking engineers.

The book is divided into four parts, the first of which is a highly mathematical consideration of the theory of the subject. Part II, entitled "Construction of the Gas Turbine," deals entirely with the details of the construction of the 1000-horsepower machine of the author's design above referred to.

Under the caption "General Comparison," Part III compares the gas turbine and the reciprocating gas engine from a thermodynamical standpoint, leading up to the conclusion that the gas turbine cycle which the author employs is not similar to the Lenoir cycle, but is much more comparable with the cycle of the free piston engine which the Humphrey gas pump resembles. A comparison with the reciprocating gas engine is then taken up from the point of view of construction and operation. Under the caption "Gas Turbine Plant" a proposed installation of three 1000-horsepower gas-turbine-driven units is described.

Part IV gives results of tests of the original gas turbine built to the design of the author by Körting Brothers of Hanover and the 1000-horsepower machine built by Brown, Boveri & Co. While these tests were disappointing, both as to capacity and efficiency, the reasons for their limitation are believed by the author to be sufficiently evident to indicate the direction in which future effort should be directed and so apparent that the realization of the author's expectation is already within sight.

STEAM BOILERS AND BOILER ACCESSORIES. By W. Inchley, lecturer on engineering at the University College, Nottingham, England. Published by Longmans, Green & Co., New York and London, 1912. Size, 5x7½ in.; illustrated; cloth. Price, $2.40.

In this book an attempt is made to treat the subject of steam boilers and boiler accessories in a manner suitable for the requirements of steam users and engineering students.

After the function of the steam power plant is explained, the various types of boilers are briefly considered. To bring out the advantages of the various types of boilers, Table 1 is given, which includes, for every type illustrated, numerical values for the pounds of water evaporated per hour from and at 212 deg. F., heating surface, grate area, ratio of the heating surface to the grate area, pounds of water per hour per square foot of the grate area and of the heating surface, and dimensions of the setting. Materials for boiler construction are then taken up, and, in connection with the subject of the brittleness of steel, special attention is called to the effect of phosphorus and nitrogen on the ultimate strength of the boiler plate. Table 2 gives 30 cases of failure in steel plates and the per cent. of carbon, nitrogen and phosphorus in each case. At the end of the chapter formulas for calculating the strength of the boiler shell are derived.

The fuels for the generation of steam are treated rather too briefly, but the subject of combustion is taken up at considerable length and in a very clear manner. Methods for calculating the air required for combustion from flue-gas analysis and the subject of coal calorimetry are considered in detail. At the end of the chapter several practical numerical examples are given.

Boiler furnaces are treated at considerable length. The various losses which take place in a boiler furnace are considered and the methods of decreasing them outlined. The conditions affecting the design of furnaces for various fuels and for different kinds of boilers are also discussed. Various types of English stokers are illustrated; these differ much from those used in American power plants. The subject of combustion of liquid and gaseous fuels is also treated at some length.

The fundamental theory of the chimney draft is explained and formulas are derived for calculating the height of a chimney to produce a given draft. In connection with the subject of mechanical draft steam jets are compared with fans and the type of boiler best suited for mechanical draft is discussed. More might have been given on mechanical draft and additional illustrations would have been desirable.

The theory of steam generation is simply and clearly explained and considerable space is given to discussing the effect of the velocity of gases upon conduction and on ultimate boiler performance. This section is well written and uptodate, except that the old values for the properties of saturated steam were retained. This might tend to confuse the reader, as the latent heat of steam at 212 deg. F. is given as 966.6 B.t.u. in the text and as 970 in the steam tables at the end of the book.

Much space is given to the details of the Lancashire and other flue boilers, and but brief mention is made of the cylindrical multitubular type. The locomotive and vertical boilers are treated briefly and do not include uptodate designs in American practice.

Water-tube boilers are covered very completely, but also represent mainly English practice.

In connection with boiler accessories, feed pumps, injectors, water and oil filters, steam and oil separators, feed-water heaters and economizers, feed-water regulators, reducing valves and superheaters are described in detail. Many good illustrations are included. The treatise on superheaters is especially complete.

In connection with steam piping the subjects of water-hammer, drainage, protection against expansion and vibration, corrosion and steam-pipe covering are considered.

The selection and treatment of boiler feed water is dealt with at considerable length and includes methods of testing water for corrosiveness and means of estimating and remedying hardness of water.

Directions for the practical running of boilers are given,

including an explanation of the use of CO_2 recorders and directions regarding the purchase of fuel.

Under steam-boiler testing the code of the Institution of Civil Engineers of England is given. This differs from the code of the American Society of Mechanical Engineers mainly in the details regarding the recording of results. The instructions regarding the duration of the test, the methods of sampling the fuel and ashes and the analysis of coals are presented very clearly. Also the directions for working up boiler tests are given in great detail.

In general the book is clear, contains much new matter, and, if edited so as to include American practice, would prove a very desirable textbook for colleges. In its present form it is a good reference book and should prove of considerable value to engineers.

❋

Lectures on Engineering Chemistry

The first of a series of three lectures by Dr. Frederick Dannerth, consulting chemist, on "Some Phases of Engineering Chemistry," was delivered before the Institute of Operating Engineers, at its quarters in the Engineering Societies Building, 29 West 39th St., New York City, on Saturday evening, Feb. 15. This lecture related chiefly to coal; its combustion and purchase by specification. The two forthcoming lectures, the dates of which have not yet been announced, will treat the subjects of boiler feed water and oils and lubrication.

SOCIETY NOTES

The Iron and Steel Institute, London, will hold its annual meeting at the Institution of Mechanical Engineers, Westminister, on May 1 and 2. At this meeting the Bessemer gold medal will be awarded to Adolphe Greiner, general director of the Société Cockerill, Seraing, vice-president of the institute. The annual dinner will be held at the Hotel Cecil, on May 1. The autumn meeting, at Brussels, will be announced later.

A reception and ball by the American Institute of Electrical Engineers, at the Hotel Astor, New York, will be the closing feature of its midwinter convention, beginning at 9 p.m., Feb. 28. As it takes the place of the annual banquet usually held in February, it will be the social event of the season, giving every opportunity for the greeting of old friends and making new acquaintances. Tickets to the reception, at $2.50 each, may be obtained from Ralph W. Pope, honorary secretary of the institute, or at the information bureau of the convention at the Engineering Societies Building, 33 West 39th St., New York. Checks made payable to R. W. Pope should accompany all requests.

OBITUARY

VICTOR HUGO

Victor Hugo, about 14 years manager and chief inspector of the St. Louis department of the Hartford Steam Boiler Inspection & Insurance Co., died very suddenly on Jan. 31 from pneumonia. He was a graduate of the University of Minnesota, a member of the American Society of Mechanical Engineers, and a man whom it was good to meet and to know. His loss will be seriously felt by all with whom he was connected.

JOHN FRITZ

On Feb. 13 John Fritz, famous mechanical and mining engineer died at his late home Bethlehem, Penn., at the age of 90 years.

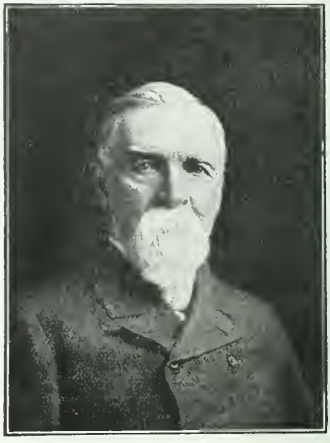
Mr. Fritz, known among engineers as "Uncle John," was born Aug. 21, 1822 in Londonderry Township, Chester County, Penn.

His early boyhood was spent on his father's farm, where he received what little education the local school offered. At the age of sixteen he became an apprentice in a machine shop, and later entered the services of the Moore & Hoover Iron Works. His mechanical proclivities enabled him to perceive the great possibilities of the iron industry. While employed there he began to specialize in machine design. From the Moore & Hoover company he went with the Morristown Iron Works, and later to the Cambria Iron Works of Johnstown, Penn.

While with this company his achievements in iron rail production were such as to attract wide attention. He revolutionized the making of iron rails, effecting a better quality and a production four-fold greater than any prevailing methods, thus enabling American manufacturers to compete with those of England and Wales. It was about this time that he also introduced improvements in blast furnace practice.

In July, 1860 he began service with the Bethlehem Iron Co. as general superintendent and chief engineer. While there he greatly assisted in perfecting the bessemer process of making steel, and also in remodeling and improving the Siemens-Martin open-hearth process. Turning his attention to structural and plate mill practice he designed mills and rolls which turned out beams, channels, etc., superior to those on the market. When the problem of making armor plate arose, he originated the solid steel plate, the superiority of which over all other forms remains unquestioned.

The success and growth of the great Bethlehem Iron & Steel plants are due largely to the efforts of Mr. Fritz, whose



JOHN FRITZ

engineering ability and accurate judgment were always productive of commendable results.

He was a member of all the principal engineering societies of this country and abroad, and was honored by many of the scientific societies of the world. The banquet given at the Waldorf-Astoria on Oct. 31, 1902 on the occasion of his eightieth anniversary and the foundation of the John Fritz medal to perpetuate his memory, was one of the most felicitous occasions in the history of American engineering.

The engineering profession has lost one of its great members, and engineers and scientific men throughout the world will mourn the loss of one whose name will forever be associated with the steel industry.

PERSONALS

F. R. Wadleigh has opened offices at 1013 Bank of Commerce Building, Norfolk, Va., as consulting engineer, on all matters connected with the preparation, purchase and use of coal. Mr. Wadleigh will give especial attention to sampling and analyses, and use of coal as fuel.

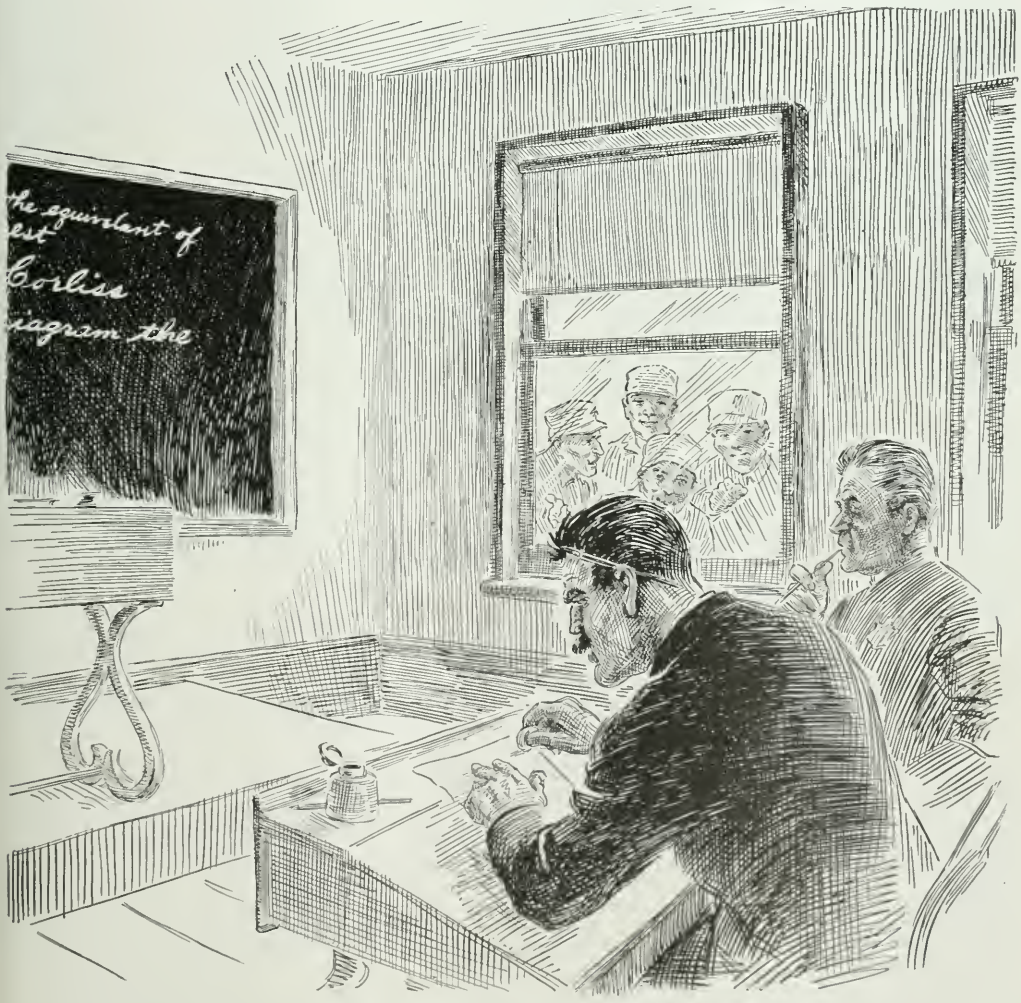
E. A. Scott, managing editor of the "Metal Worker," has been appointed secretary of the American Society of Heating and Ventilating Engineers. W. W. Macon, who has held this position for a number of years, is now a member of the board of managers.

F. William Bösch has resigned his position in the steam turbine drafting department of the General Electric Co., Lynn, Mass. After a visit to Germany, where in connection with Prof. Rössler, Mittercide, he will make a study of high-speed engines, especially investigating the Stumpf uniflow steam engine, he will, in August, assume the position of designing and consulting engineer with the Murray Iron Works Co., Burlington, Iowa.

POWER

Vol. 37 NEW YORK, MARCH 4, 1913 No. 9

The Examiners Examined



THE TABLES TURNED IN MASSACHUSETTS

(See pages 292 and 305)

Turbines and Diesel Engines in Central Stations

SYNOPSIS—Abstract of a paper recently read by M. Gercke, chief engineer of the Maschinenbaufabrik Augsburg-Nürnberg, at a meeting of the association of electric central-station managers and engineers in Kiel, Germany. The author gives an interesting comparison of the relative economic importance of steam turbines and Diesel oil engines for central-station work.

In order to get a safe basis of comparison it is essential, besides considering the technical advantages and disadvantages of the two modes of power generation, to study their respective costs of operation.

Steam-driven Generators. Their chief domain is in

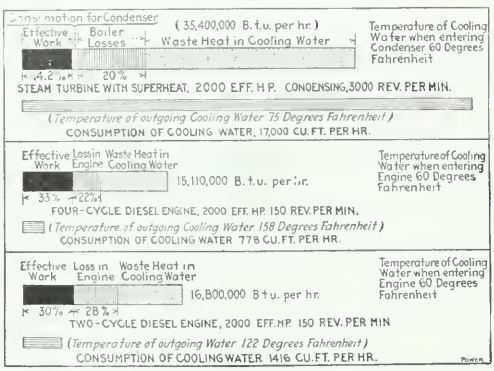

Consumption for Condenser
(35,400,000 B.t.u. per hr.)
Effective Work
Boiler Losses
Waste Heat in Cooling Water
Temperature of Cooling Water when entering Condenser 60 Degrees Fahrenheit
42%
20%
STEAM TURBINE WITH SUPERHEAT, 2000 E.F.F. H.P. CONDENSING, 3000 REV. PER MIN.
(Temperature of outgoing Cooling Water 75 Degrees Fahrenheit)
CONSUMPTION OF COOLING WATER, 17,000 CU.FT. PER HR.
Effective Work
Loss in Engine
Waste Heat in Cooling Water
15,110,000 B.t.u. per hr.
Temperature of Cooling Water when entering Engine 60 Degrees Fahrenheit
33%
22%
FOUR-CYCLE DIESEL ENGINE, 2000 EFF. HP. 150 REV. PER MIN.
(Temperature of outgoing Cooling Water 158 Degrees Fahrenheit)
CONSUMPTION OF COOLING WATER 778 CU.FT. PER HR.
Effective Work
Loss in Engine
Waste Heat in Cooling Water
16,800,000 B.t.u. per hr.
Temperature of Cooling Water when entering Engine 60 Degrees Fahrenheit
30%
28%
TWO-CYCLE DIESEL ENGINE, 2000 EFF. HP. 150 REV. PER MIN
(Temperature of outgoing Water 122 Degrees Fahrenheit)
CONSUMPTION OF COOLING WATER 1416 CU.FT. PER HR.
POWER

FIG. 1. HEAT UTILIZATION AND CONSUMPTION OF COOLING WATER OF STEAM TURBINES AND DIESEL ENGINES AT FULL LOAD

large power stations. Their advantages in general—and when turbines are employed in particular—are: unlimited capacity of units, low initial cost, as referred to the unit of output, large overload capacity, simplicity of attendance and upkeep, possibility of using all kinds of coal, even the most inferior grades, as, for example, raw brown coal, lignite, peat, etc. Their disadvantages are: dependence of heat consumption per unit output upon the character of attendance and upkeep, dangers and drawbacks associated with the use of boilers (cleaning, inspection, removal of ashes, dust and smoke nuisance), losses of fuel through starting and extinguishing fires, large consumption of cooling water by condensers, the operating condition of the latter being determinative for the economy of operation.

Oil-driven Generators. Their chief domain is in small- and medium-sized power stations. Their advantages are: high thermal efficiency, a low heat consumption per unit of output, which is practically independent of size of engine and skill of attendance; absence of smoke and fumes, immediate readiness to start, no fuel losses when starting or stopping, no trouble with dust in flues and removal of ashes; reduced purchase, replenishment and storage of fuel in tanks, less consumption of cooling water. Their disadvantages are almost nil, except the stresses exercised on the foundation by the inertia forces, which is a defect common to most reciprocating piston engines. Another drawback: Diesel engines cannot be built up to units of unlimited capacity. With horizontal twin tandem combinations the upper limit of size is 4000 hp. With vertical engines an increase of capacity up to 6000 hp. is possible, but a still further increase of the size of units is at present out of the question, as the heaviest pieces of a 6000-hp. twin-tandem engine running at 94 r.p.m., weigh already 80 tons, and must be transported by special railway cars.

Total Efficiencies. The above mentioned thermal superiority of the Diesel oil engine is not in all cases associated with a general economic superiority of the plant. The relative utilization of heat and consumption of cooling water in Diesel engines and turbines of the same size are graphically compared in Fig. 1. The figures refer to engines of about 2000 hp. output, latest design and full load. But in order to arrive at just conclusions as to the actual conditions of heat utilization, the heat consumption of the two types at partial loads must also be considered. Figs. 2 and 3 show that with partial loads the factor of fuel cost becomes less favorable in Diesel

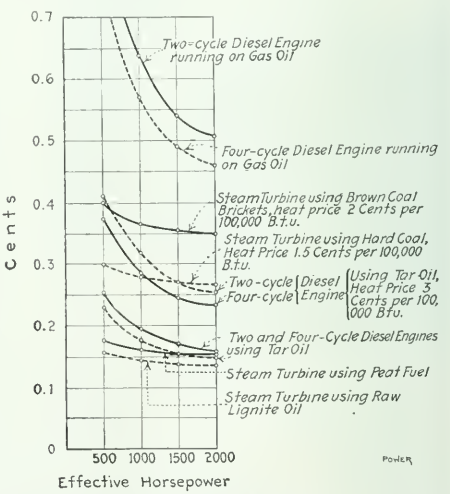

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Cents
Two-cycle Diesel Engine running on Gas Oil
Four-cycle Diesel Engine running on Gas Oil
Steam Turbine using Brown Coal Brickets, heat price 2 Cents per 100,000 B.t.u.
Steam Turbine using Hard Coal, Heat Price 1.5 Cents per 100,000 B.t.u.
Two-cycle Diesel Engine
Four-cycle Diesel Engine
Using Tar Oil, Heat Price 3 Cents per 100,000 B.t.u.
Two and Four-Cycle Diesel Engines using Tar Oil
Steam Turbine using Peat Fuel
Steam Turbine using Raw Lignite Oil
500 1000 1500 2000
Effective Horsepower
POWER

FIG. 2. HEAT PRICE IN STEAM TURBINES AND DIESEL ENGINES PER EFFECTIVE HORSEPOWER AT FULL AND PART LOADS, DISREGARDING THE EFFICIENCY OF THE ELECTRIC GENERATOR

plants. It should be added, however, that the operating conditions of the steam plant are assumed to be very favorable, namely, admission pressure of steam 12 atmospheres (176 lb.), and temperature 325 deg. C., with normal delivery of cooling water. If conditions are less favorable, the consumption of steam increases considerably.

Total Operating and Fuel Cost. The influence of fuel on the total operating cost depends on the following items:

(1) Heat consumption per unit of output.
(2) Heat price.
(3) Engine capacity.
(4) Ratio of actual operating hours to the maximum

possible operating hours per annum. In other words, the influence of fuel cost is proportional (1) to the local fuel cost, and (2) to the load factor

$$\frac{\textit{Rated capacity} \times \textit{annual operating hours}}{24 \times 365}$$

The higher these values are the greater is the importance of the fuel cost in the total operating expenses. The other items are: interest and amortization of initial capital, administration and attendance, lubrication and cleaning materials, upkeep and repair. The influence of fuel cost dominates with high heat prices and high load factor. The influence of interest and amortization dominates with low load factor and low heat prices, especially when plants serve as auxiliary or reserve. Therefore, Diesel engines are not adapted to the latter purposes, also

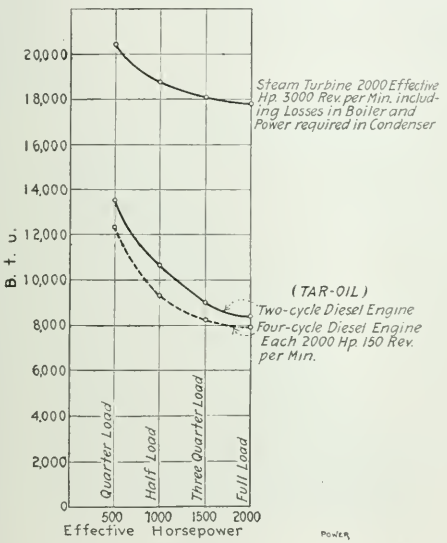


Fig. 3. Heat Consumption of Steam Turbines and Diesel Engines per Effective Horsepower at Full and Part Loads, Disregarding the Efficiency of the Electric Generator

not for covering occasional peak loads, because in this case the initial cost of the additional plant must be kept as low as possible, in order that the high interest and amortization charges may not burden the few operating hours of the auxiliary. An exception to this rule obtains in cases where immediate starting ability is required. Then the Diesel oil engine is superior to the steam turbine.

There are some cases which require special consideration, for example, when a central station is located directly at the mouth of the coal pit, which is a growing practice nowadays, or when it is situated in the midst of lignite and peat bogs, or in the direct vicinity of oil wells. In this case the fuel cost is very low and the steam turbine is superior to every other power generator, because its initial cost is small. The same holds true in the case of an electric power station which is to utilize the waste gases of blast furnaces, provided there are no steel plants or rolling mills attached to the furnaces which can use the surplus energy. Even though a gas-engine plant consumes only half the quantity of gas that the turbine-driven unit does for the same output, the latter is superior, all points considered. For this very reason there are more steam turbines and engines used in the Baku and Galician oil fields than Diesel engines.

Another case where the steam turbine is superior to the Diesel engine is when the waste heat of the plant can be utilized, especially when steam is used in considerable quantities for heating purposes. In central-station work this will hardly be the case, though in some cities, Nürnberg, for example, the waste steam of the central station is used in a public bath. If all the waste steam can be utilized the turbine becomes equal in thermal efficiency to the Diesel engine and superior in economic excellence, on account of the lower initial cost and the cheaper absolute fuel price. In the case of small Diesel plants the utilization of waste heat does not pay, because the amount available is too small to produce a sufficient quantity of steam or hot water (about 300 to 400 calories per effective

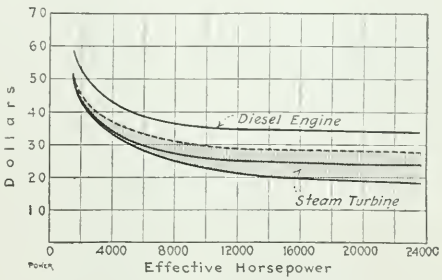


Fig. 4. Initial Cost per Effective Horsepower of Complete Power Stations, Not Including Real Estate, in Germany

horsepower-hour). In the case of larger Diesel plants the hot cooling water is preferably used in circulating heaters, and the heat of the burnt gases is utilized in economizers for preheating the feed water of boilers, as is done in the central station of Halle a.S. Finally, the Diesel oil engine is not suitable when units of over 4000 kw. or 6000 hp. are to be installed. In all other cases a comparative computation must ascertain whether a pure turbine or a pure Diesel plant is to be used, or whether a combination of the two types gives the highest economic efficiency. This is particularly necessary when an existing steam-driven central station is to be enlarged and accurate operating results are available to form the basis of comparative calculations.

Initial Cost of Complete Stations. In addition to the above reproduced curves showing heat price, heat utilization and consumption of cooling water, Fig. 4 gives a graphic idea of the comparative initial cost of the two types per effective horsepower for all sizes. The prices given refer, of course, to German conditions, but are nevertheless interesting. The number of types of Diesel engines among which a selection may be made being comparatively small, the curve of initial cost is simple. In the case of the steam turbine a great deal depends upon the selection of the units; hence the initial costs are represented in form of a strip, the lower limiting curve of which gives the minimum values, and the middle curve the normal values which may be attained. The cost of real estate and the initial expense for water supply or

cooling-tower plants are not included in either case. If these are required they are, of course, more expensive in turbine plants than in Diesel plants. The cost of attendance of both types may be considered as nearly equal, because the higher expenditures for waste and lubrication of the Diesel engine are counterbalanced to some extent by the additional expenditures for the attendance of the boiler house. In the case of large units, steam turbines are again greatly superior, in this relation, to Diesel engines. The total annual operating costs of electric central stations of 15,000 hp. = 10,000 kw., equipped with steam turbines and Diesel oil engines respectively, are graphically shown in Fig. 5.

Summary of Results. If a new central station of small capacity, say up to 1000 hp. total output, is to be built, the Diesel engine under normal conditions is the most space, no special permit required, simple fuel supply, possibility of storing large quantities of fuel in tanks without loss, are other advantages of the Diesel auxiliary. If strikes or other interruptions in the supply of coal occur, the Diesel engine is extremely useful, because it may be operated independently, the oil being pumped in automatically, and no special attendance being required. The central station of Halle is remarkable and well worth visiting for the automatism of its fuel supply. The storage and supply of coal to the boilers, even if automatic, is much more expensive and largely dependent upon the attendants, who may impair the continuity of the operation. This danger is specially imminent if the bunkers in the boiler room are not very large. Moreover, the storage of coal involves considerable heat losses and liability to self-ignition and fire.

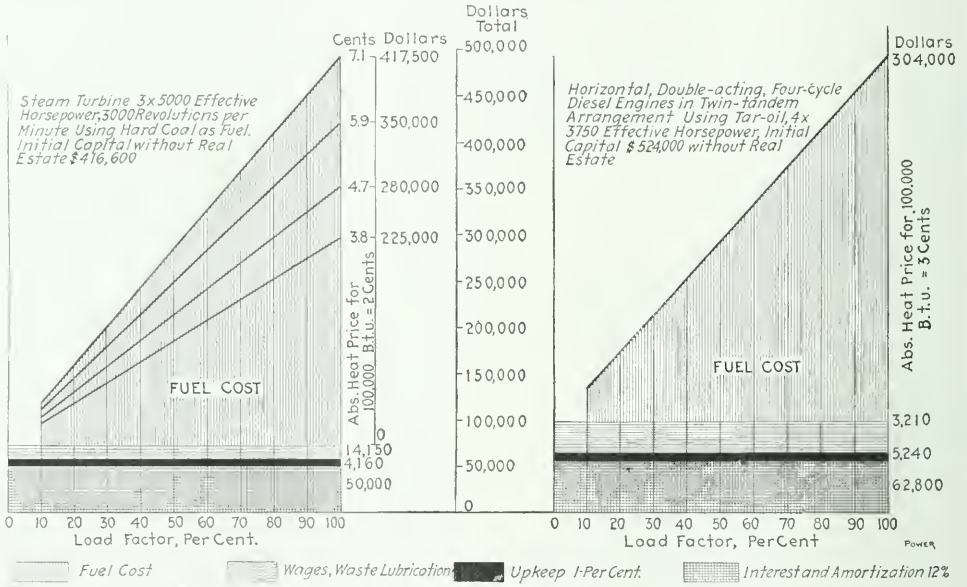


FIG. 5. ANNUAL OPERATING COST OF AN ELECTRIC CENTRAL STATION OF 15,000 EFF. HP. (10,000 KW.) TOTAL CAPACITY, IN GERMANY

advantageous mode of generation, unless special fuel conditions prompt the application of piston steam engines. Steam turbines are in no case advisable for small capacities. In the case of central stations of medium size, from 1000 to 6000 hp. total output, the steam turbine will prove superior in many cases. For capacities beyond 6000 hp. or 4000 kw. it is the only type to be adopted. Nevertheless, the large Diesel oil engine may prove an exceedingly valuable auxiliary to the steam turbine in medium and large central stations. Besides being economically comparable with the steam turbine in case of high load factor and high local fuel cost, even for large work, there is the immediate readiness to start and the avoidance of fuel losses during stoppages, which commend the Diesel engine for that purpose. Even the largest units can be started within two minutes and connected in parallel on the line, and loaded up to their full capacity. This is very convenient in case of a breakdown or a sudden increase of load in the central station. Small floor

The following conclusions are formulated by the author:

(1) For capacities of over 1000 hp. the initial capital outlay for a Diesel plant is higher than that required for a turbine plant of the same size. Hence the amount of interest and amortization per unit of output is also higher in the Diesel plant. These items, however, are of decisive importance only if the load factor of the station is low. For higher loads they drop out of the calculation. As far as the item of operating cost is concerned the Diesel engine is not to be recommended as an auxiliary. Only when the immediate readiness to start is a chief consideration is the Diesel engine superior.

(2) The cost of heat per unit capacity in Diesel engines is considerably lower than in steam turbines, provided the local price per 100,000 calories is 5c. or more, or if unfavorable water conditions prevent the utilization of the highest possible vacuum in the condenser of the turbine plant.

(3) With low load factors and low local fuel cost a steam turbine is the only mode of generation to be employed for large work, never a Diesel engine.

(4) With high load factor and high local fuel cost the case is reversed, a Diesel plant being more economical.

(5) The advantages of both types may in many cases be combined by installing Diesel engines and steam turbines together, the former taking care of the continuous load or part of it, and the latter of the peak loads, occurring during few hours of the day. This distribution commends itself on account of the lower initial cost of the steam turbine and of the possibility of augmenting the output of high-pressure boilers for some time. Quite a number of combined plants of this character are already in operation on the European continent.

Smoke Prevention

By A. C. Wilson

SYNOPSIS—Some suggestions for burning coal with a minimum of smoke. The author points out that the chief difficulty as regards smoke legislation is to prove that a chimney so habitually emits smoke as to be a nuisance.

Increased attention is being paid every year to the public nuisance caused by smoke from factory chimneys, but considerable ignorance as to the real problem involved is often shown by those most active in complaining of the smoke nuisance. Such legislation as exists only imperfectly provides for the detection of offenders.

Among other fallacies are the following: (1) That smoke is caused by incomplete combustion of coal due to insufficient air being supplied to the furnace; (2) that the loss of heat due to incomplete combustion represents a considerable proportion of the total heat in the coal and (3) that smoke can be easily prevented.

As regards legislation, the principal difficulty is to establish a basis on which it can be easily proved that a particular chimney so habitually emits smoke as to constitute a nuisance. Such laws as exist either leave each case to be fought out on the general ground of whether a nuisance exists, or, if it is attempted to make any clearer definition, the emission of black smoke is prohibited.

Even if there could be no question as to whether smoke is black, smoke of less density may be as great a nuisance as black smoke in respect to pollution of the atmosphere. The nuisance is caused by sending particles of unburnt carbon or hydrocarbons into the air, and the density of smoke may be reduced to almost any degree by simply diluting it with air without altering the total amount of solid matter emitted. To compare the amount of preventable smoke discharged from two chimneys it is necessary to know the amount of coal being burnt in the furnaces. Many so called smoke-preventing devices simply aim at diluting the gases with excess air during the time smoke is most likely to be given off.

Very few boiler furnaces fail to supply sufficient air for the complete combustion of the coal fired in them. About 12 lb. of air is necessary to supply the oxygen for completely burning 1 lb. of coal and under actual conditions most furnaces pass from 20 to 30 lb. of air per pound of coal. The reason smoke is emitted is that the air is not intimately mixed with the carbon and is not at a sufficiently high temperature.

The problem of insuring complete combustion of bituminous coal is mainly one of temperature and involves continually keeping the furnace at a high temperature, which is by no means easy. In the first place, the gases are reduced in temperature by coming in contact with the comparatively cold boiler plates; again, the furnace temperature is lowered every time fresh coal is thrown on the fire. One must, therefore, aim at preventing any gases from coming in contact with the heating surfaces except such as are products of complete combustion and also at introducing fresh coal in such a manner as to avoid reducing the furnace temperature either by reason of the low temperature of the coal itself or by the rush of cold air accompanying it.

To fire in such small quantities that the amount of green coal on the bars at any time is insufficient to appreciably reduce the furnace temperature would involve continuous work such as no human being would perform.

Possibly the best attempt at smokeless hand firing can be attained by adopting the coking system, that is, firing green coal only on the dead plate and the front part of the grate and gradually pushing it to the back after all the hydrocarbon gases have been driven off and it has become an incandescent mass. This method of firing, however, is impossible unless the boiler is worked at a low rate, as the coking process, during which the hydrocarbons are given off, is comparatively slow and the effect is to reduce the available grate area of the boiler by about one-half. If boilers are worked at a high rate it is impossible to fire them by hand without smoke and the only practicable cure generally is to increase the number of boilers.

Mechanical stokers more nearly comply with the conditions for smokeless combustion because the coal is fed without opening the fire doors and in small quantities at a time, if not continuously. That they do not always succeed in working without producing smoke is generally due to the attempt to force the fires. This results in a low furnace temperature because there is too much green coal on the bars.

A sharp draft is absolutely necessary for maintaining a high furnace temperature and the greater the amount of coal burned per square foot of grate, the sharper must be the draft, otherwise a fire is obtained which is incandescent underneath and more or less green on the top. Further, the draft must be well distributed or the fuel bed will develop holes, as happens with some types of forced-draft furnaces where the draft is produced by blowers or steam jets.

Such furnaces often give a fire having several bright patches in a bed of green coal and the half-burnt gases from the green coal never become intimately mixed with

the hotter products and consequently pass away as smoke. Unless smoke is consumed in the furnace it never will be consumed; it may be so diluted as to be light in color, but the objectionable matter is being expelled into the air just the same.

As to the common fallacy that smoke necessarily represents a large waste of fuel, a chimney may be smoking badly and yet the amount of heat lost by incomplete combustion may be negligible. The writer has tested the gases at the base of a number of smoky chimneys and has found that an average of 1 per cent. of carbon monoxide in the gases is very seldom reached. As high a percentage as this is only obtained when there is little dilution with excess air and when the carbon dioxide present is high, say, 10 to 12 per cent.

Assuming the composition of the flue gases to be carbon dioxide (CO_2) 12 per cent., carbon monoxide (CO) 1 per cent., oxygen 6 per cent., nitrogen 81 per cent. and the calorific value of the fuel to be 12,500 B.t.u. per lb. the heat lost by incomplete combustion represents about 5 per cent. of the total available heat in the fuel, which is much less than many imagine.

❋

Power Transmission by Compressed Air*

SYNOPSIS—Why compressed air has been considered as an inefficient means of power transmission and improvements made by manufacturers which have brought it to an equality with electrical transmission.

❋

In steam-driven machines of the oldest type the horizontal design was used, with the steam and air cylinders in tandem. No water jackets or spray cooling arrangement were provided for the air cylinder, and the piston speeds averaged from 200 to 300 ft. per min. The air valves were of the heavy flat type or of rubber, clearance spaces were anything and the compressor single-stage.

Present-day designs are mostly vertical and of the inclosed type employing forced lubrication and water jacketing for the cylinders. For pressures from 70 to 100 lb. the compressor is generally two-stage. In a general way the above description covers the major portion of compressed-air plants with piston speeds up to 500 or 600 ft. per min. Valve gears of combined mechanical and automatic type, or of light multiple-ported small-lift types, are employed and clearance spaces are down to 2 or 3 per cent. When in some instances old compressors of the first mentioned design, or somewhat similar, were discarded and a new plant installed, the results obtained easily explain why compressors have for long been considered inefficient. To demonstrate what can be done by installing new machines a case is mentioned where a compressor of four times the capacity of the old machine taken out required only the same amount of steam per hour.

When considering the general question of compressed air efficiency it is necessary not only to examine the compressor, but the pipe lines and the plant consuming the air must be considered; in this direction there has been great improvement. Taking a wide view of the matter few engineers have given much study to compressed air and have taken for granted that what has been must still continue. Looking at the matter from this standpoint, what is generally found in inquiries issued for large compressors? The capacity of the machine is given; if steam driven, steam pressure and vacuum are mentioned; if electrically driven, voltage. It is not general that steam consumption is asked, and on very rare occasions is a capacity test called for. Such a test when made is seldom, if ever, any check on the output of the machine, the test generally being to fill a reservoir of given capacity from atmospheric pressure to final working pressure. The temperature of the air may be taken or may not, and when taken is generally misleading and possibly allows of error up to 10 per cent. In fact it is questionable whether there is one compressor at work at the moment, the actual capacity of which is known correctly through a test.

The actual proof that any given machine is really delivering the full amount of air specified is not, of course, sufficient to prove the machine the best possible, as some designs may require more power to compress the air, due to small restricted air passages, poor cooling arrangements, low mechanical efficiency, etc. On the other hand a machine may not have a long life at a high state of efficiency. After all what the user wants is a machine to show small horsepower for air actually delivered, and a figure representing horsepower to compress say, every 100 cu.ft. of air, covers volumetric efficiency, mechanical efficiency, losses in compression, etc.

Taking a reciprocating two-stage air compressor, it will be found that a figure such as 20.5 electrical horsepower is required to compress and deliver every 100 cu.ft. of air up to 100-lb. pressure. Such a figure might reasonably be expected as "covers" for, say, 90 per cent. motor efficiency. For steam-driven machines the indicated horsepower in the steam cylinder per 100 cu.ft. of air compressed as above, should be about 20.

Passing to present designs and bearing in mind the present tendency to install more of such plants in collieries and shipyards, it might not be out of place to give an idea of the general tendencies. First it is found in a general way that colliery units range from about 1000 to 5000 cu.ft. and the electrically driven units from 1000 to 3000 cu.ft. with unit horsepowers from, say, 200 to 600. These represent plants placed on the bank and power drawn from local power companies' mains. In some quarters there seems to be a tendency to try in the mine smaller semi-portable sets of strong and efficient design, with more attention given to strength and simplicity than was hitherto the case, when lightness was considered the main necessity.

Comparing overall efficiency of the electrical methods with a large steam-driven compressor on the bank, Mr. Barr gives the following losses. In the steam-driven machine the mechanical loss is 10 per cent. and transmission losses including leakage 7 per cent. For the electrical plant assume the current generated at the power house, as it will be found in a general way that the losses in the generation will equal the extra charge for the power as made by the power company. Then there are 10 per cent.

*Abstract of paper read by George Barr before the Manchester (Eng.) Association of Engineers.

mechanical loss in the engine, 10 per cent. loss in the dynamo, 5 per cent. loss in the transmission for the small semi-portable machines and 10 per cent. loss in the motor driving the compressor. For large motor-driven machines the same allowance of 7 per cent. loss for air transmission must be made as in the steam-driven sets, and for the small semi-portable sets there is a loss of 3 per cent. for the short air piping and leakage. These figures are all relative, but are a fair mean for all the cases. Steam losses therefore equal 17 per cent., large motor sets 37 per cent., and small motor sets 38 per cent., or a difference of 20 and 21 per cent., respectively, representing a margin to cover extra price paid to power companies, or a figure which will make it possible to decide whether extra interest could not be readily paid on the extra capital for the steam-driven sets, together with the difference in running cost and upkeep of both schemes.

Mr. Barr reviewed the changes which have taken place in detail of construction, such as cooling arrangements, governing, lubrication, valve gear, etc. Summarizing he finds with a large installation of four machines of, say, 2500 cu.ft. capacity each, first, no automatic stopping gear is wanted, as there will be an attendant who can be made use of for any starting or stopping actually wanted over a given day. But if in an electrically driven plant one of the sets had a variable-speed motor to give a desired range when all the plant was in use, this would cover all actual requirements. However, an additional controlling gear arranged to allow so much air to be discharged before compression starts, would give a plant covering all possible fluctuations and assure high efficiency over varying conditions, with the extra advantage of being reasonably cheap.

At the moment automatic valve gears are those most used, and certainly it would appear that the greatest progress has been made in this class. They take the form of a multiple-ported or grid valve with very small lift, the form of valve, fixings and springs being covered more or less by various patents. Should an examination be made of indicator diagrams taken from one of the latest high-speed machines with multiple-ported valves, it would be apparent that the losses due to throttling either on the inlet or discharge are very small and leave little margin for improvement in this direction.

Where it was common to install single-stage machines for pressures of say, 60, 80 and even 100 lb., two-stage compression is now most common. An increase in compressor efficiency of say, 10 to 15 per cent. is obtained in large size units, which also makes for greater reliablity due to absence of heating troubles. Further, cooler and drier air in the system can be secured, but it is necessary to have intercoolers of reasonable size, 1 sq.ft. of cooling surface for every 4 cu.ft. of air compressed to 100 lb. not being too large. The intercoolers are also better if placed outside the engine rooms in the atmosphere, say on the shaded side of the building. The cylinder cooling in the best makes of machines may be taken as generally the most efficient possible, as most compressors now have jackets carried entirely around the cylinders and covers.

Referring to the question of reheating, Mr. Barr admits that it would certainly add considerably to the efficiency of a compressed-air installation. In collieries however, the air is not used at one particular spot; to heat the air immediately after leaving the compressor to, say, 350 deg. F. and then pass it along a distance of perhaps 1000 ft. is simply wasting money.

With newer designs of machines where piston speeds are higher, more care must be taken of air-cylinder lubrication. In fact, more trouble develops from the use of unsuitable oils in the cylinders than is necessary. The same conditions do not prevail in an air cylinder as in the average steam cylinder, where condensation can always be depended upon to assist towards lubrication. In the air cylinders, although there is moisture in the air, this will not deposit at the high temperature. In fact, the air cylinders will run very dry and seizures will be the rule if proper care is not taken. For air-cylinder lubrication an oil with high flash point is needed, which will leave little or no deposit, such as high-class gas-engine oil.

These remarks do not refer to compressors other than the usual machines for pneumatic tools and uses requiring similar pressures. For higher pressures machines of three- and four-stages are necessary.

Air compressors can now be had very much higher in efficiency than ten years ago. More care is being taken in the layout of piping systems, and if this betterment were carried into the plant which consumed the air, there would be shown in such places as collieries, results equal to the best electrical schemes. This statement does not suggest that over an instantaneous reading an overall efficiency could be shown with air equal to electricity, but taking a year's comparison with all upkeep charges, running cost and interest on differences in invested capital, or in other words the cost per ton of coal raised averaged over a year, the costs would be much the same. This is the correct test and the efficiency which really matters.

Power Plant Operation in the Army

Brig.-Gen. Weaver, chief of the Coast Artillery Corps U. S. A., in his recent report to the Secretary of War, has this to say of the corps method of training its men in the operation of the electric power plant:

The War Department some years back provided courses of instruction for officers and enlisted men at the Coast Artillery School at Fort Monroe, Va., that had for their object precisely the training of selected officers and enlisted men for these technical duties.

Accordingly there are among the commissioned personnel of the coast-artillery officers who are designated as "artillery engineers," and among the enlisted personnel noncommissioned staff officers with the grades of "engineer," "fireman," "master electrician," "electrician sergeant" (first and second class) and "master gunner," whose duties relate particularly to the care, preservation and maintenance of the electrical and mechanical equipment in condition of thorough serviceability.

Based on the estimates of the National Coast Defense Board, the percentages of completion of electrical installations necessary for full protection of home ports are: Search-lamps, 41 per cent.; power plants, 50 per cent., and submarine mines and structures, 81 per cent.

The power plant at Fort Monroe is operated entirely by enlisted men of the Coast Artillery Corps under the supervision of the head of this department of the school.

The results obtained in the operation of this plant have been very satisfactory, an average daily power and lighting output of 1200 kw.-hr. for the 12 months

ended Feb. 29, 1912, having been produced at a cost per kilowatt-hour at the switchboard of 3.38c., including all supplies, repairs, labor and depreciation, or of 1.19c., excluding labor and depreciation costs.

It is estimated that the installation of this plant and its present use for post lighting, pumping, fortification, school and heating purposes has resulted in a decrease in the total annual maintenance cost of the school and post of Fort Monroe of approximately $25,000; or, making allowance for labor of all enlisted personnel involved and for depreciation cost of plant, is an annual net commercial saving of over $13,000.

It is indicative of the high opinion held of this plant in commercial circles that some of the most prominent manufacturers of engineering apparatus in the United States have cited it as exemplifying in a noteworthy manner the efficiency that can be obtained with isolated plants of comparatively small capacity.

The Examiners Examined

The position of chief of the boiler-inspection department of Massachusetts, which department has also charge of the examination and licensing of engineers, became vacant in July of last year and in October a civil-service examination open to members of the department was held. Only seven of the nineteen examiners took the examination and only three of these obtained the 65 per cent. necessary to qualify.

The following list of questions is sent to us as those asked upon this occasion. They do not seem to overweigh in difficulty those which the examiners are in the habit of asking, as evidenced by questions said to have been asked by them and sent to us for solution.

Civil Service Examination
held Oct. 14, 15, 1912, for
Acting Chief Inspector of Boilers.
Commonwealth of Massachusetts.

Mathematics: (Given weight of 3 in 15)

9 practical problems, including one to be solved by logarithms.

Spelling: (Given weight of 1 in 15)

20 words selected from the Boiler Inspection Law.

Letter: (Given weight of 2 in 15)

To consist of 300 words written on a choice of three subjects, namely—What are the prime requisites of a first-class engineer? Why did you select engineering as a life work? Which is the most important qualification in an engineer: mechanical ability or good morals?

Penmanship, including copying: (Given weight of 1 in 15)

Copy a section of law.

Practical and Technical Examination: (Given weight of 8 in 15)

Consisting of the following 36 questions:

1. Sketch all the essential parts of a compound-spring steam gage, registering both pressure and vacuum.

2. How many B.t.u. are required to change one pound of ice at zero F. to steam at atmospheric pressure?

3. What is meant by absolute zero of temperature, and how many degrees below zero on the Fahrenheit scale is it?

4. Show by figures what height a column of water will be balanced by a pressure of 14.7 lb.

5. The low-pressure cylinder of a cross-compound engine is doing more work than the high pressure. State fully how you would divide the work evenly between the two cylinders.

6. Do these indicator diagrams (representing one diagram taken from each end of the cylinder of a steam engine without taking the paper from the indicator drum) show that at any time during the stroke the resistance to the piston's forward motion is greater than the effort tending to move it forward? If so, indicate the point where this is so and show by figures approximately how much the resistance exceeds the effort and also state fully why the engine does not stop at or near the point you have indicated. Use pair of ordinary slow-speed four-valve cards.

7. The temperature of steam supplied to an engine is 531.169 F. and the temperature of the exhaust is 219.452 F. What is the thermal efficiency of the engine?

8. If a condenser is added to the above engine so that the temperature of the exhaust is lowered to 153.123 F., what will be the increase in thermal per cent.?

9. As the difference in temperature of the steam on entering and leaving the cylinder of a steam engine is increased, what source of waste is greatly increased, and how can this waste be partially avoided?

10. A vacuum gage on the condenser of a steam engine shows a reading of 27 in.; what is the absolute pressure in pounds per square inch in the condenser? Barometer reads 30 in.

11. What is the most accurate way of ascertaining the steam consumption of a steam engine per indicated horsepower, and how may the steam accounted for by the indicator be obtained from the indicator diagram? What is the value of such a determination?

12. Name the various places where an indicator may be advantageously attached and state what information you would expect to obtain from cards taken from the places you have named.

13. What does the term "slip" mean as applied to a pump? With a pump in good working order, about what per cent. of the capacity of the pump does the slip amount to?

14. What does the term "pump duty" mean? Give an example.

15. How would you determine how large a feed pump would be required to feed the boilers of a given plant?

16. In feeding a boiler with an injector against its own steam pressure, where does the power come from, and could the same injector be used to feed a second boiler carrying steam at a higher pressure?

17. How would you calculate the size of a steam main needed for a battery of boilers using 10,000 lb. of soft coal per hour. The highest pressure carried is 150 lb. absolute and the lowest 100 lb. absolute. The specific volume to be taken as 3.1 and 4.4 respectively.

18. An horizontal tubular boiler with 30.27 ft. of grate is under forced draft and 50 lb. coal per sq.ft. grate per hour is burned. The boiler works at 150 lb. absolute pressure. Determine size of required safety valve.

19. Show the best method of staying the lower part of the rear sheet in a cylindrical multitubular boiler, having a manhole in the front head.

20. A plain slide-valve engine has $\frac{3}{4}$-in. outside lap on the valve and $\frac{1}{4}$-in. exhaust lap. Suppose one-half to be taken off inside lap at each end. What changes will take place in the events of the stroke? Explain by cards.

21. What tests are necessary to determine the suitableness of steel plates of steam boilers? State in full as to the proper requirements, physical and chemical.

22. What is meant by priming in a boiler? Would the temperature of steam at a given pressure vary with different degrees of priming?

23. Steam from a 150-hp. engine using 26 lb. of steam per horsepower per hour exhausts into a surface condenser at a pressure of 4 lb. absolute, the temperature of the condenser water being 55 F. on entering the condenser and 95 F. on leaving the condenser. How many pounds of condensing water are required per hour for this engine?

24. A surface condenser is to be attached to an engine capable of developing (condensing) 350 hp. The amount of steam per hp. per hour is 19.5 lb. How much cooling surface should the condenser have?

25. What is the difference between the real and apparent cutoff of an engine and how is the real cutoff found when the apparent cutoff and clearance are known? Give an example.

26. The indicated horsepower of an engine is 563.74 and the net horsepower is 484.25. What is the mechanical efficiency of the engine?

27. Describe an inside and an outside fusible plug, and state why the distinction is made and where each should be used.

28. Why is it difficult to lift hot water on a long lift with an injector?

29. Why are two wristplates used on the low-pressure cylinder of a compound- or triple-expansion Corliss engine?

30. What do you understand by a "balanced valve" in a steam engine? Name some balanced valves.

31. When is steam said to be saturated and when superheated?

32. Design and calculate a double-riveted butt joint, furnishing your own data.

33. If a pop valve of a boiler is set at 100 lb. and the same fails to blow when the gage indicates 110 lb., what would be the first step to ascertain the reason for its failure to blow at 100 lb.?

34. Suppose two boilers of the same dimensions with equal grate area, one carrying 100 lb., the other 160 lb. Which requires the largest safety valve? Why?

35. State the possible advantages and disadvantages of the so called "high lift" spring safety valve as compared with the ordinary lift valve.

36. State in full how you would proceed with an investigation as to the cause of a boiler explosion, when there had been serious damage to property or loss of life.

F. T. Monorail System

The F. T. (fixed tongue) monorail system consists of a single I-rail with the wheels of the trolley running on the lower flanges of the rail. The main feature is the means of switching from one track to another without the operator leaving the cab.

On approaching a track switch at which the operator desires to run from the main to the spur track, a steering lever on the trolley near the controller is pulled. This raises a horizontal roller to a position in which it engages

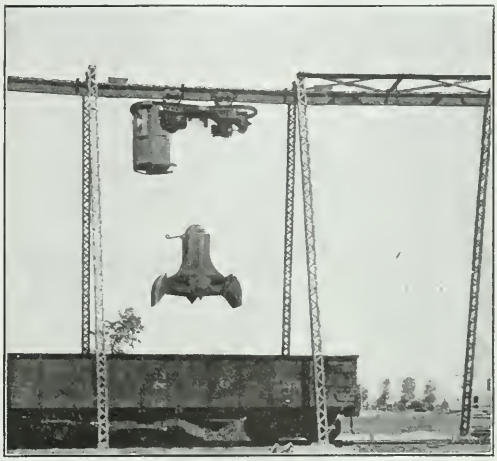


FIG. 1. UNLOADING A COAL CAR

a curved rib on the underside of the central switch tongue and swivels the leading track, thereby diverting the trolley onto the spur track.

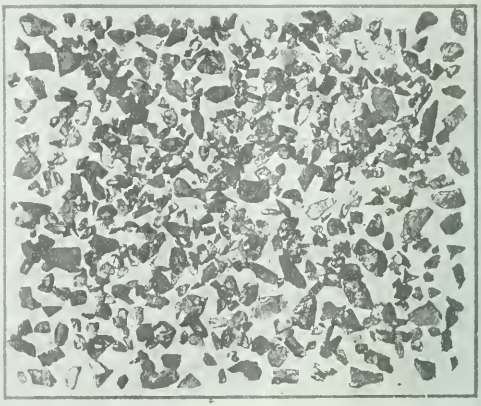
FIG. 2. DUMPING INTO THE STOKER HOPPER

The system is suitable for power-plant work in unloading coal from cars, as shown in Fig. 1, and for dumping it into the stoker hoppers, as shown in Fig. 2, where a load has just been dumped.

This system is made by the Shaw Electric Crane Co., Muskegon, Mich., and handled by Manning, Maxwell & Moore Co., 85 to 89 Liberty St., New York City.

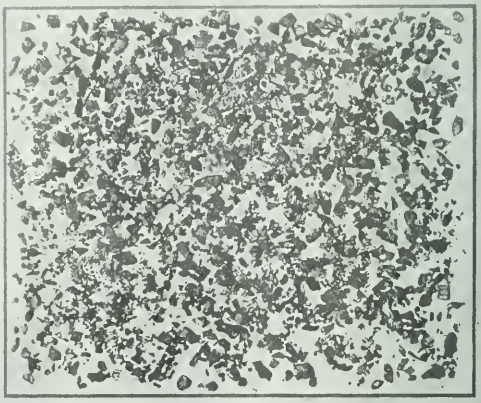
Anthracite Coal Sizes—Actual

PEA



No 3 - BUCKWHEAT OR BARLEY

No 1 - BUCKWHEAT



No 4 - BUCKWHEAT OR CULM

No 2 - BUCKWHEAT OR RICE

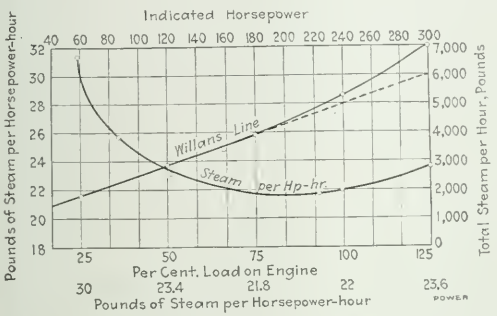
Standards for anthracite-coal sizes as recommended by the American Society of Mechanical Engineers and printed in the Society's *Journal*, November, 1912.

ame	Screen or Opening (Circular) Through or Over Which Coal Will Pass, Inches: Through	Over
Pea	$\frac{3}{4}$	$\frac{5}{8}$
No. 1 buckwheat	$\frac{5}{8}$	$\frac{3}{8}$
No. 2 buckwheat	$\frac{3}{8}$	$\frac{5}{16}$
No. 3 buckwheat	$\frac{5}{16}$	$\frac{3}{32}$
No. 4 buckwheat or culm	$\frac{3}{32}$	

The sizes specified by the New York City Department of Water Supply, Gas and Electricity are practically the same as the above except for pea coal, which is specified as coal which will pass through ¾-in. and over ½-in. openings.

Load Curves from Ideal Corliss Engines

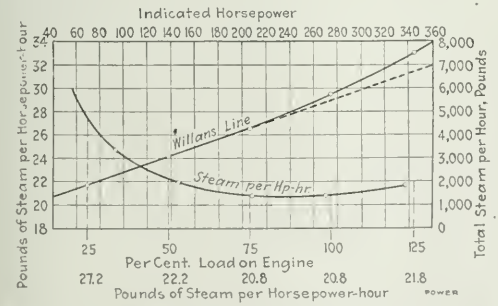
On a recent visit to the shops of A. L. Ide & Sons, at Springfield, Ill., the editor found one of their new four-valve engines upon the testing floor, and was shown the very complete arrangements and apparatus which they have for determining the consumption of their engines. A request for some of their test results has brought the accompanying curves, which are full of interest, showing


Indicated Horsepower
40 60 80 100 120 140 160 180 200 220 240 260 280 300
Pounds of Steam per Horsepower-hour
Total Steam per Hour, Pounds
Willans Line
Steam per Hp-hr.
Per Cent. Load on Engine
25 50 75 100 125
30 23.4 21.8 22 23.6
Pounds of Steam per Horsepower-hour
POWER

Curves from First Test. Dry-saturated Steam. 124 Lb.

the low consumption attained by the use of superheat and the sustained efficiency of the engine through a wide range of load.

The engine is of the high-speed, four-valve type and was described in Power of July 2, on page 35. The tests from which the curves reproduced herewith were plotted, were made upon a 16x22-in. engine running at 200 r.p.m. exhausting into the atmosphere. The first test was made on Mar. 26 of this year with dry-saturated steam of 124-lb. gage at the throttle. The minimum consumption is 21.7 lb. at 200 hp., or 83⅓ per cent. of the full load.


Indicated Horsepower
40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360
Pounds of Steam per Horsepower-hour
Total Steam per Hour, Pounds
Willans Line
Steam per Hp-hr.
Per Cent. Load on Engine
25 50 75 100 125
27.2 22.2 20.8 20.8 21.8
Pounds of Steam per Horsepower-hour
POWER

Curves from Second Test. Dry-saturated Steam. 150 Lb.

The total amounts of steam required at various loads are as follows:

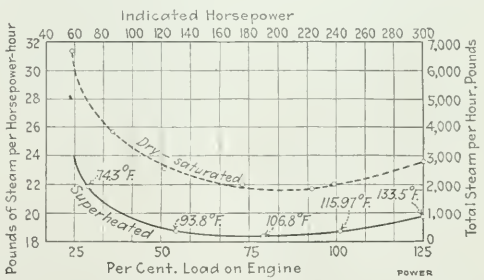
Load per cent. of rating	Load hp		Steam lb. per hp.-hr.		Total steam lb. per hour
25	60	×	30	=	1800
50	120	×	23 4	=	2808
75	180	×	21 8	=	3924
100	240	×	22 0	=	5280
125	300	×	23 6	=	7080

If these values be set off upon the ordinates corresponding to the respective loads to the scale at the right, and the points connected, the Willan's line, or line of total steam consumption, will be produced. This line runs straight up to about the point of least steam consumption per horsepower but rises as the efficiency falls off with the overload. The best result, 21.7 lb. per i.hp.-hr., corresponds with a Rankine efficiency of 71.8 per cent. and a thermal efficiency, charging the engine with heat above that which it could furnish to the feed water, of 11.6 per cent.

The test from which the second curve was plotted was made upon the same engine on May 7 under the same conditions except that the steam pressure was 150-lb. gage, 25 lb. higher than in the test just considered. With this pressure the rated capacity of the engine is 275 hp., and its steam consumption at various loads was as follows:

Load per cent of rating	Load hp.		Steam lb. per hp.-hr		Total steam lb. per hr.
25	68 75	×	27 2	=	1870
50	137 5	×	22 2	=	3052
75	206 25	×	20 8	=	4290
100	275	×	20 8	=	5720
125	343 75	×	21 8	=	7494

The Willan's line has the same characteristics as be-



Curves from Third Test, 125-lb. Steam, Superheat 74 to 133 Deg.

fore. The best steam consumption is 20.7 lb. at about 240 hp. or 87.3 per cent. of the rated load. This is a Rankine efficiency of 70.47 per cent. and a thermal efficiency of 12.11 per cent.

The test from which the third curve was plotted was made with steam of 125 lb. pressure with superheat varying from 74 deg. F. at one-quarter load to 133 deg. at 25 per cent. overload. The lowest steam rate was 18.3 lb. per hp.-hr., at about 190 hp. This represents a Rankine efficiency of 78.7 per cent. and a thermal efficiency of 13 per cent. The curve of the test with saturated steam at the same pressure is indicated upon this chart by a dotted line.

**

One of the largest dams in Europe was officially put in service on Nov. 16 in the presence of the German Emperor. The dam spans the Bober valley in the Prussian part of Silesia and forms with the dam at Marklissa the backbone of the high-water protection project planned in 1900. It is 920 ft. long at the crest and 460 ft. at the base, 200 ft. high on an average, 24½ ft. thick at the crest and 161 ft. at the base. Cyclopean masonry amounting to 332,000 cu.yd. was used in the construction. The capacity of the reservoir is 1,760,000,000 cu.ft. and the area of the surface is 600 acres, forming a lake 5¼ miles long. Together with the necessary real estate purchases the cost of the dam was $2,150,000.

ELECTRICAL DEPARTMENT

Motors and Motor Applications II.

By A. B. Morrison, Jr.

Variable-speed Induction Motors

The great disadvantage of the alternating current as compared with the direct current is the inability to obtain a simple motor which will give constant horsepower with variable speed. In general, there are two types of variable-speed motors: one is constant horsepower variable speed, or, to put it another way, a variable-torque variable-speed motor; the other type is constant-torque variable-speed motor in which the horsepower is proportional to the speed. There is no alternating-current motor in which the first class of speed control can be obtained.

There are several methods by which the speeds of induction motors may be varied. These are, briefly: Varying the frequency, changing number of poles, varying the rotor resistance, using two or more motors connected in concatenation and varying the applied voltage. Of all these methods, only two are commonly used in ordinary motor applications; these are: Changing number of poles and varying the rotor resistance. The others are applicable only in very special cases.

The speed of an induction motor is equal to

$$\frac{60 \times \textit{frequency in cycles per second}}{2 \times \textit{number of poles}}$$

From this it is evident that the speed can be decreased by increasing the number of pairs of poles. This is accomplished by using either one winding with a controller so arranged that the connections can be changed to give one-half or double the number of poles or, where several speeds are required, by using separate windings with a controller arranged as described. Usually the squirrel-cage type is used for this purpose, because it is necessary then to change only the stator connections. A wound rotor can be used, but in this case it is necessary to change the rotor connections also. Usually multi-speed induction motors are designed for full and one-half speed or in some cases, for four speeds as 1800, 1200, 900 and 600 r.p.m. The last speed range mentioned is not practicable for anything but squirrel-cage motors.

A motor in which the speed is altered by changing the number of poles is essentially a constant-torque motor and the horsepower is proportional to the speed. At any given speed the operation of the motor is stable; that is, it will operate at a constant speed dependent on the number of poles and independent of the load, barring, of course, the slight drop in speed from no load to full load. The speed changes occur in steps, however, and not gradually; for instance, with the motor operating at a synchronous speed of 1800 r.p.m., the next lower speed is 1200 r.p.m., and there is no intermediate speed. With a wound-rotor motor it would be possible to use a resistance for getting speed variations between any two fixed speeds, but the arrangement would be cumbersome and the speed control not suited to many classes of work.

The disadvantages of the pole-changing method of control are the great number of connections required if the speed variation is to be greater than 2 to 1, the necessity of opening and closing the primary circuit every time the speed is changed, and the decreased power factor at the lower speed. The efficiency of changeable pole motors is approximately the same at all speeds. Also, the maximum and starting torques are approximately the same as for standard motors of the same size and type.

By using a wound-rotor motor with a resistance which can be adjusted by means of a controller the speed can be adjusted below normal. Such a motor gives a constant torque at any given speed and load; hence the horsepower is directly proportional to the speed. The speed, however, is very unstable and a slight change in load will cause a great change in the former. For certain classes of work, such as fans, where the load is constant for any given speed this type of motor can be used provided efficiency is of no particular importance. Its action is very similar to that of a direct-current shunt motor with a resistance in series with the armature. The efficiency at any speed below normal is low because the motor draws full load current from the line and the current not needed actually to perform the work is dissipated as heat in the resistance. Furthermore, the resistance is bulky and occupies considerable space. Where it is necessary to run the motor for short periods only at reduced speeds as for crane or similar work, this type of motor is very satisfactory. Its greatest application is for hoists of various sorts.

Synchronous Motors

Aside from the induction motor the only other type of alternating-current multiphase motor much used in general work is the synchronous motor. This is used, however, only in large sizes and for special applications. Its starting torque is low, but in large sizes and slow speeds particularly it possesses marked advantages over the induction motor, because of its corrective effect on a lagging power factor.

The synchronous motor is practically a revolving field alternator operating as a motor. It can be started by means of a starting compensator, the same as a squirrel-cage induction motor, or by means of a small induction motor. In the latter case the synchronous motor is brought above speed, the induction motor is cut out, and the synchronous motor is allowed to drop in speed until in synchronism with the line when the switch is closed. By over-exciting the fields a leading current can be obtained and this leading current helps to compensate for the lagging current present when induction motors are operated.

When supplied with some type of damping device a synchronous motor will have a starting torque, when started by means of suitable starting compensator, of from 20 to 40 per cent. of full load torque and a "pull in" torque (torque at the moment the machine reaches synchronism) of 15 to 35 per cent. The maximum torque

is about twice the full load torque. Due to the difficulty of starting without drawing excessive current from the line the synchronous motor should be used only where it has to be started and stopped infrequently. If the starting torque is heavy, the motor should be connected to the shafting by a clutch. It should also be remembered that a synchronous motor does not indicate being overloaded by slowing down, but if loaded beyond its maximum capacity it stops suddenly. Also, its speed at any load is constant, dependent only on line frequency.

Single-phase Motors

The use of single-phase motors is confined, for the most part, to sizes below 10 hp. There are several reasons for this. While there are several forms of single-phase motors on the market, for present purposes, they can be divided into two general classes, induction and compensated repulsion.

The induction single-phase motor is very similar, in appearance, to the ordinary multiphase-induction motor. They differ in their method of starting, but when once up to speed their action is the same. The stator winding is very similar to that of a three-phase induction motor and the rotor is usually of the squirrel-cage type or a modification of this, although it may be of the wound-rotor type.

Single-phase induction motors possess no starting torque. To bring them up to speed two general methods are used; namely, phase splitting and repulsion starting. In the former method two windings are used in the stator of the motor: one of these is the working winding, the other the starting winding. These are supplied from the single-phase source and the current in the starting winding is caused to lag behind that in the working winding by means of reactance. This sets up an imperfect rotating field, which is sufficient to bring the motor up to speed under light load, after which the starting winding is usually cut out. There are several different ways in which this "phase splitting" is accomplished. In some cases an external starting box is employed to secure the necessary phase difference in the current, in others the reactance is part of the secondary winding itself.

Where a single-phase induction motor is started by the "repulsion" method the rotor is similar to the armature of a direct-current motor, being provided with form wound coils and a commutator. There are two sets of brushes, bearing on the commutator, these sets being short-circuited upon each other. The stator is supplied with single-phase current, and there is no electrical connection between the stator and the rotor. The currents in the stator set up a flux which reacts on the rotor, repelling the successive coils and thereby causing rotary motion. When the motor approaches synchronous speed a centrifugal device of some description short-circuits the commutator bars and lifts the brushes, transforming the motor into the induction type with practically a squirrel-cage rotor.

The single-phase induction motor, with phase splitting starting device, is suitable for machines in which the starting torque is not over 150 per cent. of full load torque. Almost invariably some type of clutch is used which allows the motor to attain nearly synchronous speed before picking up the load. The starting current with 150 per cent. of full load torque is approximately 250 per cent. of full load current, and the maximum torque is from 150 to 200 per cent. of the full load torque. The speed regulation from no load to full load is good, being better than in the multiphase motor. In general, however, the efficiency, power factor and maximum torque are not as good as in corresponding multiphase motors. They are suited only for driving machinery where the starting torque required is light.

The single-phase induction motor with the repulsion method of starting has a starting torque of from 2 to 2½ times full load torque, with 2 to 2½ times full load current.

The second general type of single-phase motor mentioned is the compensated repulsion motor, in which the line current passes through the stator and also through the rotor by means of two sets of brushes bearing on the commutator. There is also a second set of brushes set at an angle to the first which are short-circuited on themselves. This motor differs from the straight repulsion type in that it contains two additional sets of brushes and the stator and rotor are in electrical contact.

The compensated repulsion motor has a starting torque of 2½ to 3 times full load torque with approximately twice full load current, and the maximum torque is from 3 to 3½ times full load torque. The power factor is very high at all loads, but the efficiency is lower than in the induction motor. This type of motor is well adapted for loads where heavy starting torque is required with sudden overloads. It has the disadvantages of having a commutator and is somewhat more noisy than the induction motor after the latter is up to speed.

If a variable-speed single-phase motor is required, some form of compensated repulsion motor is generally used. The behavior of the motor is very similar to that of the variable-speed wound-rotor multiphase-induction motor with resistance in series with the rotor. It is consequently, owing to its unstable speed characteristics, suited only to such applications as require a steady horsepower at given speeds. Its characteristics as regards starting torque, etc., are unchanged when used for variable speeds. The resistance is inserted in series with the brushes which are normally short-circuited and the insertion of additional resistance decreases the speed. By the insertion of resistance in series with the brushes carrying the line current it is also possible to raise the speed of the motor slightly above synchronism.

[Direct-current motors will be considered in a future article.—Editor.]

Experience in Substation Wiring

By Thomas G. Thurston

Three large 60-cycle transformers were installed to take the place of four motor-generators in a substation which the writer was operating. Up to the time of installation only 25-cycle current had been generated, mostly for rotary converter substations, current for 60-cycle, 1000-volt distribution for the outlying districts being furnished by motor-generator sets each consisting of a 25-cycle synchronous motor direct connected to a 60-cycle, 1150-volt generator. As the 60-cycle system had grown to such proportions as to warrant the installation of a separate generating and transmission system, transformers were installed in the substations and the motor generators were used for emergency and peak-load service.

Shutting down the motor generators rendered the running of the exciters for field excitation unnecessary and

the highest voltage exciter was taken out and sent to another substation.

All the high-tension switches were remote controlled, solenoid- or motor-operated by direct current supplied from the operating busbars which also supplied current for the signal lights, overload relays, etc. These busbars was connected to the exciter busbars when the exciters were running and in case of emergency could be thrown onto a 60-cell, 100-amp.-hr. storage battery. The switchboard lights were connected the same way.

When the exciters were shut down the first problem was to furnish a source of supply for the switchboard and pilot lights. Of course, they could have been carried on

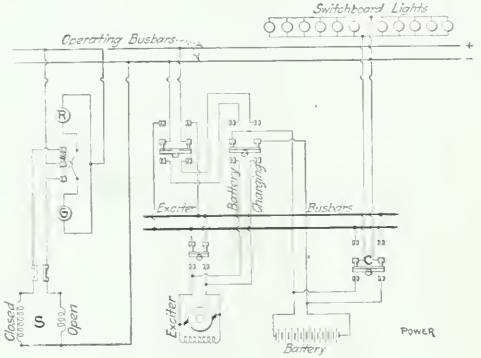


FIG. 1. ORIGINAL CONNECTIONS

the battery, but this was not advisable for several reasons, chief among which was the frequent charging of the battery, thus made necessary. This would have required running a 75-kw. exciter under practically no load for several hours every day, added to this was the increased maintenance and depreciation and risk of the battery being out of service in an emergency.

The operating busbars, of course, had to be supplied from the battery which was the only source of direct current, but this was comparatively insignificant as compared to the current required for the switchboard and signal lights. The original connections are shown in Fig. 1.

After the change a 10-kw., 2200- to 110-volt transformer was connected as shown in Fig. 2 to supply current for the lights when the exciters were shut down. A third wire *A* was run parallel to the operating busbars. The positive connections of the signal lights *R* and *G* and the top clips of the switch *C* for the switchboard lights were disconnected from the operating and exciter busbars respectively and connected to this third wire. The negative top clip of the switch *C* was disconnected from the exciter busbar and connected to the negative operating busbar.

The lower clips of the switch *B* were connected to the transformer, the top right-hand clip to the positive operating busbar, and the switch blades to the third wire *A* and the negative operating busbar. By throwing switch *B* down and switch *C* up the signal lights and the switchboard lights were connected to the transformer. When switch *B* was thrown up they were carried on the operating busbars. This was generally done when the exciters were running and the operating busbars were fed through the exciter busbars through switches *J* and *L*.

The next problem was to provide some means of charging the battery. The high-voltage exciter had been used for this purpose and when it was taken out we were unable to charge the battery with all cells in series by means of any of the remaining exciters. To overcome this difficulty the battery was cut in two and connected to a double-pole, double-throw switch *E*, as shown. In charging, the switch *E* is down and when in service it is up. Throwing the switch down connects the two sections of the battery in parallel, requiring a little over half the normal voltage of the battery to charge it. Throwing the switch up connects the two sections in series.

Everything went along nicely until one night the transmission line to the substation broke down and the room was suddenly thrown into darkness. After some groping an attendant finally located the switch for the switchboard lights and threw it onto the battery circuit. To prevent a recurrence of this trouble a 2-cp. lamp was connected across the battery terminals, as shown at *D*, Fig. 2. This was screwed in when darkness came on and out at daylight.

A surprising complication appeared when the signal lights were carried on the transformer. Referring to Fig. 2, *R* and *G* are respectively red and green lights, red indicating the switch *S* closed and green open, *H* and *I* being the opening and closing coils of the solenoid-operated switch *S*; *F* is the operating switch. Everything was normal until *F* was closed, when the lights would both burn and the one that should have been out would burn with about double its normal brilliancy. For illustration, suppose it was desired to close the switch *S*, it being indicated in the open position. The switch *F* would be closed up. Immediately the light *G* would double

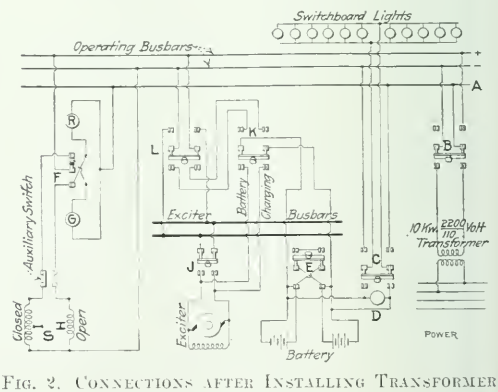


FIG. 2. CONNECTIONS AFTER INSTALLING TRANSFORMER

its brilliancy; when *S* would operate and close, *R* would light as it should, but *G* would remain, showing with double brilliancy when it should have been out, until *F* was opened when it would go out. If *F* was closed down with *S* in the position indicated the red light would appear with double brilliancy and *G* show normal. This held good in either position of *S*, closing *F* either way would show both lights and the one that should be out, with double brilliancy; testing across the switch *F* from the blade to either clip showed approximately 170 volts; the transformer voltage was 110, the battery 120. Where did the excess voltage come from and why did the two lights burn?

GAS POWER DEPARTMENT

Gas Engine Jacket Circulating Systems

By A. C. Wilson

Systems of jacket-water circulation fall into three general classes: gravity, pump and thermo-siphon. The term used in each case to describe the system refers to the force which causes the flow.

If there is a natural head of water available and the quantity is such that it is not necessary to economize, a very simple system may be employed. An inlet pipe is led to the bottom of the jacket and an outlet from the

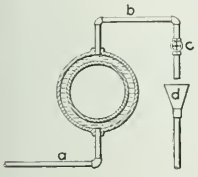


FIG. 1

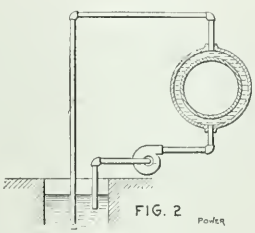


FIG. 2

top which is carried to the nearest available drain. A regulating cock is required which should be placed on the outlet pipe and it is important that the outflow be visible, partly so that the temperature may be noted easily, but principally so that the jacket cannot run dry from any cause without the fact being observed. Fig. 1 shows such a system where *a* is the inlet pipe, *b* the outlet, *c* a stop or regulating cock, and *d* a tundish into which *b* delivers.

Circulating systems in which a pump is used may be arranged in a variety of ways; the principal thing to look after is provision for the circulation being maintained or, at any rate, not being altogether stopped should the pump fail.

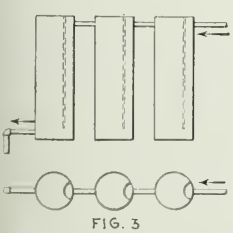


FIG. 3

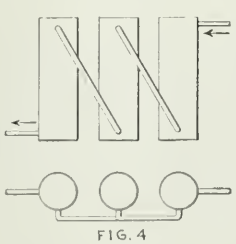


FIG. 4

Assuming the source of supply to be a large overhead tank, a gravity system may be installed, as Fig. 1, with the addition of a pump to return the water to the tank. In the event of the pump failing there would still be several hours' supply available in the tank until the pump has been repaired.

In Fig. 2 the source of supply is at a lower level than the engine and a pump is used to pump the water directly through the jacket. This arrangement is faulty because in the event of anything happening to the pump the circulation is at once stopped. A better arrangement here would be to fit an overhead tank and pump the water direct to the tank, allowing it to flow by gravity through the jacket.

Hard or sedimentary water causes trouble in circulating systems, especially where fresh water is being continually used, as it chokes the pipe connections and puts down scale on the liner. If there is plenty of water available, however, the jacket can generally be kept below the temperature at which the lime salts are deposited, although there will always be a certain amount of scale. To keep the outer surface of the liner at too low a temperature introduces other troubles, such as a cracked liner or seizing of the piston.

In towns, where the cost of water would be a considerable item if run to waste continuously, cooling tanks are commonly used and unless there is some special reason for using a pump, a natural circulation is obtained, due to the difference in density between the hot water leaving the jacket and the relatively cold water entering it; this arrangement is sometimes called a thermo-siphon. As the driving force is that due to the difference in weight of two columns of water the tanks must be placed well above the cylinder or only a very small force can be obtained and in consequence the circulation will be slow.

Tank circulation has several advantages over any other system, among which may be mentioned:

Economy in water.

No power required for pumps.

Circulation automatic and not liable to be stopped by failure of a pump.

The same water being used over and over again, there is less deposit put down if the supply originally contains much lime.

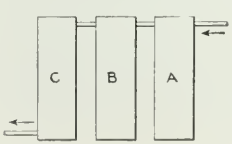


FIG. 5

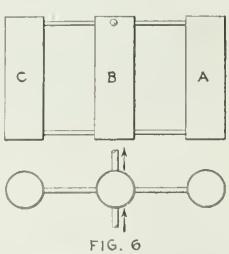


FIG. 6

The number and size of tanks necessary to cool the water depends on their location. Because of the risk of freezing it is not usual to place the tanks outside, but they should be in such a position as to get a good current of air about them. About 30 gal. per horsepower is usually sufficient if the tanks are arranged in such a way as to insure proper circulation.

Figs. 3, 4, 5 and 6 show different methods of connecting circulating tanks which the writer has met with. Figs. 3 and 4 are quite satisfactory as no short-circuiting is possible with either of these arrangements. In Fig. 5 the pockets have been omitted and in consequence water will short-circuit tanks *A* and *B*, and in Fig. 6, where both the flow and return are connected to the center tank, most of the water in circulation would never find its way into the side tanks at all.

If the water level is allowed to fall below the mouth of the return pipe, circulation is stopped and it is a wise

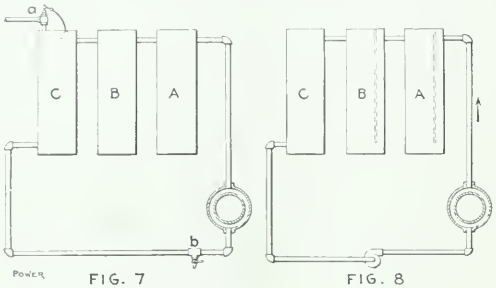


FIG. 7

FIG. 8

precaution to connect the makeup supply through a ball tap, although many people rely on the attendant watching this and filling the tank with a bucket from time to time as required.

Should the tanks become too hot, it is the practice of some engineers to open a waste tap in the flow pipe or jacket and let a little water run continually to waste, the ball tap making up the deficiency. This, however, is a doubtful expedient, as it may very easily stop the circulation of the water altogether or perhaps reverse its direction.

When circulating in the usual way the water does not stand at the same level in each tank, being highest in tank *A*, and lowest in tank *C*. If the ball tap is continually running the level in tank *C* is raised, and the circulation in consequence may be stopped, or if the flow from the ball tap is sufficient it may be reversed. If the circulation is reversed the jacket will get the water which is flowing from the ball tap and the system becomes a simple gravity system, but if the level in tank 3 is not raised sufficiently to reverse the circulation, it is quite possible for the jacket to be overheated while cold water runs in at *a* and out at the bottom of the system from the drain tap *b*, Fig. 7.

Sometimes a pump is placed in the flow pipe, as in Fig. 8, to assist the circulation, but when this is done the capacity of the pump must be carefully regulated to suit the rate of flow between the tanks.

Governor Valves for Gasoline Engines

By L. J. Watson

The practice of using butterfly valves, actuated by some sort of automatic mechanism still continues to quite an extent with gasoline engines wherein the speed is automatically governed by throttling the mixture.

Just why this style of valve is still used for this service the writer is unable to say, for when its efficiency is compared to that of the twin-piston valve, Fig. 1, it is plain that the butterfly valve requires a much greater throw of the operating rod in order to effect the same opening or closure.

To make this point clear compare a 2-in. butterfly valve with a twin-piston valve of the same diameter, each being connected to a 2-in. supply pipe and actuated by the same type of controlling mechanism. A twin-piston valve 2 in. in diameter has a circumference of a little more than 6 in.; therefore each piston commands a port 6 in. long, making a total port length of approximately 12 in. Both ports openings at the same time, it would require the valve to be moved only ¼ in. from the closed position to produce an opening equal to that of the 2-in. supply pipe.

Now consider the opening produced by a butterfly valve (*F*, Fig. 2), 2 in. in diameter and actuated by a crank arm 1 in. long. A ¼-in. throw at the end of the crank arm by the governor rod will move the wings of this valve ¼ in. at two points of its circumference only, and this movement will be mostly lengthwise of the pipe; whereas, to effect opening, it should be in a direction crosswise of the pipe.

Of course, when the valve has been turned on its axis to an angle of 90 deg. from the closed position, the movement at the point of the wings will then be crosswise of the pipe; but the crank arm will have to move through the same angle, which would require a movement from the operating rod of about 1⅜ in., or, over five times that

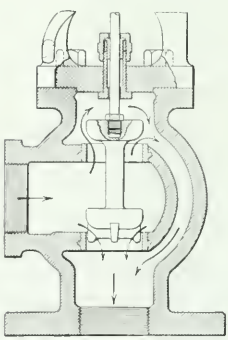


FIG. 1. TWIN PISTON VALVE

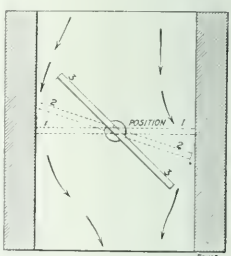


FIG. 2. BUTTERFLY VALVE

for the twin-piston valve. The opening then would not be fully equal to that of the pipe, as the thickness of the valve occupies a small portion of the space.

Furthermore, the most usual position of the butterfly-valve operation is at, or in the neighborhood of, 45 deg. from the full open or closed position, as shown in Fig. 2, position 3. From this the closing and opening effect produced by a given movement of the operating rod is much less than that produced with the twin-piston valve.

The twin-piston valve is balanced; the butterfly valve is not, and as a result, even in gasoline-engine service, where the pressures controlled never exceed 15 lb. (atmospheric pressure) it will naturally resist movement slightly more than the twin-piston type—a matter of significance when it is considered that the valve is moved by a force produced by disturbing the balance of two equal opposing forces.

HEATING AND VENTILATION

Downward Ventilation in a Rockford School*

With a view to reducing the excessive heat losses frequently found in hot-blast heating and ventilation and to attain a temperature practically uniform in all parts of the room with a noticeable absence of drafts, Clinton E. Beery recently installed a system for the Hall School Building, Rockford, Ill., differing in its principles of operation from the usual hot-blast system.

To control the temperature of the air at the ceiling a coil consisting of three 1¼-in. pipes suspended 20 in.

FIG. 1. ONE OF THE ROOMS EQUIPPED WITH DIFFUSERS AND CEILING COILS

below the ceiling, was extended entirely around each room approximately 5 ft. from the exposed walls and 6 ft. from the inside walls. At a point just below the level of the coils fresh air is introduced into the room through a specially constructed diffuser which breaks the current and directs the air in all directions over the breathing zone. The foul-air exits are at the floor line in the four corners of the room. On arriving at the breathing zone, static pressure forces the air out of the room at the floor line, producing a movement of air downward at a velocity of approximately 2 ft. per min., with no appreciable evidence of lateral drafts or air currents. This condition is not disturbed until below the top of the exits, and even then there is no noticeable air movement over the floor, due to the comparatively small exits drawing on a large volume. Each vent screen in this particular installation contains 1.1 sq.ft. clear area, which equals 1.1 sq.ft. for each room, the cubic contents of the room approximating 10,800 cu.ft.

During January of 1912, room No. 3 was fitted up for experimental work to demonstrate the system. This room was in the northwest corner of the first floor, and consequently was the coldest room in the building. Room No. 8 on the second floor, directly above, was an exact duplicate in size, and results obtained in the two rooms were used as a basis of comparison. Each room is 26x31 ft. with the ceiling 13 ft. 6 in. high. Each has a 100 sq.ft. of glass exposure facing the west and 50 sq.ft. of glass

TABLE 1.—MAXIMUM AND MINIMUM OF ROOM TEMPERATURES DURING TESTS

Room	Northeast Corner	Northwest Corner	Southeast Corner	Southwest Corner
3	70–67	71–70	70–68	69–67
8	83–80	70–68	69–66	69–64

TABLE 2—TEMPERATURE OF ENTERING AIR DURING TEST

Readings....	1	2	3	4	5	6	7	8	9	10	11	12
Room No. 3..	74	70	72	73	70 5	73	70	71	73	70	73	69
Room No. 8..	68	76	109	76	98	72	80	94	68	97	65	83

TABLE 3—TIME RECORDS ON HEATING ROOM TO 68 DEG. F.

	Initial Temp., deg F	Rise, Deg. F	Time a.m.	Time Required
Room No. 3...	38	30	8:50	1 hr. 20 min.
Room No. 8... ..	42	26	9:25	1 hr. 55 min.

exposure facing the north. During the month a comparative test of temperatures was made in the two rooms. Room No. 8 was supplied with 60 sq.ft. of wall radiation in the northwest corner. The air delivery to each room was 1544 to 1560 cu.ft. per min., measured at the exits. Twelve temperature readings were taken at 5-min. intervals, in each corner of both rooms, and also twelve readings of the temperature of the entering air. The out-

FIG. 2. SHOWING UNIFORM DOWNWARD DISTRIBUTION DURING STEAM TEST

side temperature at the time of the first reading was 2 deg. below zero, and at the time of the last reading, 3 deg. below zero. An extremely cold west wind estimated at 18 to 20 miles per hour was blowing. The maximum and minimum of the twelve corner readings are given in Table 1, and the temperature of the entering air for the twelve readings in Table 2.

The relative humidity readings in room No. 3 showed 63 per cent., and in room No. 8, 51 per cent. Observations of the relative time required to heat the rooms to 68 deg. F. were taken with the heat turned on at 7:30

*Abstract of paper read before the American Society of Heating and Ventilating Engineers.

a.m. Table 3, giving the results, shows a margin of 35 min. in favor of room No. 3.

No difficulty was encountered in operating room No. 3 with the same apparatus while meeting the requirements of the remainder of the building. With the encouraging results obtained, the Hall School was equipped throughout during the summer of 1912 with the new method and has been in operation since Sept. 1. The building is of brick, with wood floor construction, two stories in height, with basement. It contains five regular school rooms on each of the two floors, with wardrobes, recitation rooms, principal's office and corridors. The contents above the basement comprise 124,500 cu.ft. The mechanical equipment consists of a multivane No. 13 fan, direct connected to a side-crank engine operating at 174 r.p.m. All radiation and Vento blast coils are operated on the Webster system of vacuum heating. Johnson Service temperature regulation with intermediate control is used in each room. All galvanized ducts from the plenum chamber are of regulation design.

Table 4 gives the velocity and delivery records of all

TABLE 4—RECORDS OF VELOCITIES AND DELIVERIES AT VARIOUS EXITS

Room	Northwest Exit	Northeast Exit	Southeast Exit	Southwest Exit	Total Delivery Cu.ft. per Min.
1	270	384	326	400	1518
2	390	394	396	350	1683
3	390	400	450	314	1709
4	332	354	460	446	1751
5	364	360	334	332	1529
6	336	346	345	342	1506
7	352	406	354	350	1586
8	434	428	448	366	1843
9	344	328	356	384	1553
10	412	336	370	282	1590

exits for ten 1-min. readings taken after the system had been put in operation, and following is a summary of the observations which have been made since.

A temperature of 85 deg. at the ceiling has been found to be sufficient as a maximum. The temperature throughout the breathing zone is controlled within a range of 1 deg. F. in all parts of the room. Air never enters the room above 73 or 74 deg. F.

There is no noticeable effect on the conditions of the room caused by the glass exposure, but tests showed a slightly higher rapidity in downward movement of the air several inches in from the glass.

There is an entire absence of drafts or currents, and the cold surface of desks and furniture does not contrast against high temperatures of atmosphere surrounding them, as is often complained of in other systems.

During the week of Dec. 15, tests were conducted by the school authorities to determine the efficiency of the system. The temperature was maintained uniformly at 68 deg. and the humidity at 58 per cent. To demonstrate that no cross-currents existed, live steam was introduced into the room through the diffuser in the ventilating system. The steam distributed equally throughout the room and dropped gradually toward the floor like a blanket until it reached the level of the exits through which it escaped. Another test comprised the suspending from wires of a large number of silk threads 36 in. long, to which were fastened pieces of tissue paper. The absence of any swaying of these pieces of paper showed that there were no cross-currents generated by the ventilating system.

From results already obtained, economy of operation is evident, but previous to the time the paper was presented, no efforts had been made to determine the comparative saving. Complete data on this point will be available at a later date and it will be interesting to learn how the economy of the new system compares with the usual type of installation.

CORRESPONDENCE

Use of Pitot Tube in Air Measurements

In the Feb. 4 number of POWER, Frank L. Busey in an article under the above title devotes one paragraph to the coefficient by which the velocity or velocity head at the center of a duct must be multiplied to give the average velocity or average velocity head over the entire cross-section. Several approximate values of the factor are given, but the indiscriminate use of a figure as high as 0.95 would, in many instances, lead to grave errors in fan testing.

Tests recently conducted on a novel air-heating apparatus made it necessary to determine this factor with considerable precision for a 12½-in. circular duct. A study was made of the data for a 16-in. duct contained in Frank H. Kneeland's paper (referred to by Mr. Busey) with the following results:

Type of Pitot Tube	Average Velocity	Center Velocity	Ratio: Av. Vel. / Center Vel.
U.S. No. 1 ...	18,692	19,410	0.963
Gebhardt No. 1	19,138	20,710	0.924
Gebhardt No. 1	20,918	23,080	0.906
Taylor No. 3..	14,374	15,670	0.949
U. S. No. 1..	13,924	14,820	0.939
Gebhardt No. 1.	14,054	15,590	0.901

Not only were the results discordant as far as establishing a ratio of velocities was concerned, but there was a considerable disagreement between pairs of observations, which were taken to represent similar conditions except for the type of tube used. Therefore, the criticism of Naval Constructor Taylor* in the discussion of Mr. Kneeland's results: "The experimental results given by Mr. Kneeland cannot be regarded acceptable to those who like myself are firm believers in the accuracy of pitot tube methods, provided proper pitot tubes are used" seemed none too severe, and a set of experiments was undertaken to establish the ratio, Average velocity ÷ Center velocity, for working conditions. The results of these experiments were communicated to the American Society of Naval Engineers in November, 1912, in a paper: "The Pitot Tube Applied to the Measurement of Air," and as the same may not be available to all interested, a summary is given herewith.

Two standard Taylor pitot tubes were mounted in a 12½-in. circular duct in such a way as to enable one tube to traverse the horizontal diameter and the other to traverse the vertical diameter. These tubes had independent connections to a gage, which was so arranged with stop cocks as to permit of registering the velocity head from either tube, and the gage was fitted with an additional pair of equalizing cocks which could be opened to the atmosphere between tests in order to check the zero reading of the draft gage. The single divisions on the scale of the draft gage were 0.01 in.; and 0.001 in. could be estimated closely. Half-inch intervals were etched on one of the ⅛-in. pipes connecting to the pitot tube.

*Transactions, A. S. M. E., Vol. 33, 1911, page 1168.

TABLE 1. RESULTS OF TESTS TO DETERMINE RATIO OF AVERAGE VELOCITY TO CENTER VELOCITY

Test No.	Barometer, in. of hg.	Relative humidity, per cent.	Temperature air, deg. F.	Static pressure of air, in. of water	Vapor pressure, lb. per sq.in.	Abs. static pressure, lb. per sq.in.	Density of dry air, lb. per cu.ft.	Density of vapor, lb. per cu.ft	Density of moist air, lb. per cu.ft	Velocity Head—inches of water: Center of inlet pipe	On 1-in. dia.	On 2-in. dia.	On 3-in. dia.	On 4-in. dia.	On 5-in. dia.	On 6-in. dia.	On 7-in. dia.	On 8-in. dia.	On 9-in. dia.	On 10-in. dia.	On 11-in. dia.	On 12-in. dia.	$\sqrt{\text{Head}}$ at center	Av. $\sqrt{\text{head}}$	Ratio av. vel. to center vel.	Av. head in. of water	Center vel., ft. per min.	Lb. of air per hr.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
1	30.13	56	27	46.3	0.66	0.18	14.67	0.0782	0.00036	0.0786	0.0709	0.0704	0.0701	0.0693	0.0683	0.0676	0.0674	0.0669	0.0658	0.0631	0.0551	0.0426	0.2663	0.2472	0.9282	1042.0		
2	29.61	54	17	43.5	0.74	0.16	14.48	0.0777	0.00027	0.0779	0.0690	0.0685	0.0681	0.0673	0.0663	0.0656	0.0654	0.0649	0.0638	0.0922	0.0855	0.0748	0.3299	0.3037	0.9444	1260.8		
3	29.98	45	10	50.0	1.06	0.15	14.64	0.0788	0.00024	0.0790	0.0712	0.0708	0.0705	0.0698	0.0688	0.0682	0.0680	0.0675	0.0663	0.1397	0.1317	0.1190	0.4003	0.3766	0.9407	1563.2		
4	29.96	42	51	50.0	2.32	0.15	14.70	0.0779	0.00023	0.0781	0.0715	0.0710	0.0708	0.0701	0.0691	0.0685	0.0683	0.0678	0.0666	0.1443	0.1377	0.1190	0.4003	0.3766	0.9407	1563.2		
5	29.92	42	51	50.0	2.32	0.15	14.70	0.0779	0.00023	0.0781	0.0715	0.0710	0.0708	0.0701	0.0691	0.0685	0.0683	0.0678	0.0666	0.1443	0.1377	0.1190	0.4003	0.3766	0.9407	1563.2		
6	29.88	38	84	51.0	0.84	0.14	14.71	0.0778	0.00021	0.0780	0.0715	0.0710	0.0708	0.0701	0.0691	0.0685	0.0683	0.0678	0.0666	0.1443	0.1377	0.1190	0.4003	0.3766	0.9407	1563.2		
7	29.88	39	03	56.0	3.70	0.18	14.72	0.0771	0.00021	0.0773	0.0709	0.0704	0.0701	0.0693	0.0683	0.0676	0.0674	0.0669	0.0658	0.0631	0.0551	0.0426	0.2663	0.2472	0.9282	1042.0		
7-a	30.20	55	35	45.0	0.93	0.17	14.89	0.0796	0.00022	0.0799	0.0715	0.0710	0.0708	0.0701	0.0691	0.0685	0.0683	0.0678	0.0666	0.1443	0.1377	0.1190	0.4003	0.3766	0.9407	1563.2		
8	30.20	54	93	45.0	0.93	0.16	14.90	0.0797	0.00023	0.0799	0.0715	0.0710	0.0708	0.0701	0.0691	0.0685	0.0683	0.0678	0.0666	0.1443	0.1377	0.1190	0.4003	0.3766	0.9407	1563.2		
8-a	30.01	79	00	17.8	3.77	0.25	14.75	0.0785	0.00040	0.0789	0.0724	0.0719	0.0717	0.0709	0.0699	0.0693	0.0691	0.0686	0.0674	0.1467	0.1395	0.1205	0.4052	0.3848	0.9497	1594.0		

TABLE 2. PITOT TUBE DATA FROM TESTS BY PROF. C. C. THOMAS

Test No.	Barometer, lb. per sq.in.	Relative humidity, per cent.	Temp. of air, deg. F.	Static air press., in. of water	Abs. air press., lb. per sq.in.	Density of dry air, lb. per cu.ft.	Density of vapor, lb. per cu.ft.	Density of moist air, lb. per cu.ft.	Velocity head—inches of water: Center of inlet pipe	On 1-in. dia.	On 2-in. dia.	On 4-in. dia.	On 6-in. dia.	On 8-in. dia.	On 10-in. dia.	On 11-in. dia.	On 12-in. dia.	On 13-in. dia.	On 14-in. dia.	On 15-in. dia.	$\sqrt{\text{Head}}$ at center	Av. $\sqrt{\text{head}}$	Ratio av. vel. to center vel.	Av. head in. of water	Center vel., ft. per min.	Lb. of air per hr.
1	2	3	1	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
1	14.2315	63	82	0.430	14.2470	0.07327	0.00167	0.07492	0.150	0.150	0.148	0.143	0.138	0.136	0.133	0.131	0.128	0.117	0.100	0.3873	0.3573	0.922	0.1277	1560	8,955		
2	14.2315	63	83	0.655	14.2532	0.07314	0.00172	0.07422	0.230	0.230	0.228	0.222	0.216	0.210	0.205	0.200	0.196	0.175	0.145	0.4796	0.4498	0.919	0.1963	1932	11,080		
3	14.2315	63	84	0.930	14.2651	0.07300	0.00178	0.07412	0.336	0.336	0.330	0.320	0.310	0.302	0.294	0.287	0.282	0.252	0.208	0.6905	0.6496	0.918	0.3245	2501	14,220		
4	14.2315	63	85	1.085	14.2717	0.07287	0.00183	0.07470	0.405	0.405	0.395	0.383	0.373	0.363	0.355	0.347	0.340	0.305	0.250	0.8300	0.7882	0.912	0.3824	2729	15,410		
5	14.2315	63	85	1.520	14.2863	0.07261	0.00195	0.07284	0.562	0.548	0.538	0.520	0.516	0.500	0.485	0.475	0.450	0.420	0.355	0.7430	0.6802	0.915	0.4627	3000	16,990		
6	14.2315	63	89.5	1.765	14.2903	0.07252	0.00210	0.07352	0.640	0.632	0.622	0.605	0.592	0.572	0.562	0.538	0.515	0.475	0.400	0.8000	0.7273	0.909	0.5289	3234	18,110		
7	14.2366	63	91	2.070	14.3013	0.07207	0.00220	0.07345	0.710	0.705	0.685	0.670	0.650	0.627	0.610	0.595	0.575	0.525	0.455	0.8426	0.7654	0.908	0.5858	3414	19,080		
8	14.2366	63	90	1.150	14.2881	0.07221	0.00213	0.07355	0.385	0.385	0.378	0.365	0.357	0.348	0.340	0.332	0.320	0.292	0.248	0.6205	0.5689	0.917	0.3237	2512	14,070		
9	14.2366	63	85	0.460	14.2332	0.07287	0.00183	0.07402	0.125	0.125	0.123	0.120	0.117	0.114	0.112	0.109	0.102	0.099	0.080	0.3536	0.3256	0.921	0.1038	1428	8,145		

The procedure was as follows: With the fan speed constant a traverse was made with the horizontal tube, a reading taken at each of 23 points across the pipe, and at the same points on the return. The same was followed by a traverse with the vertical tube and each set repeated twice, making a total of 276 observations in each set. The fan speed was then increased and the procedure repeated for the additional points covering the range of fan capacity. The data from the tests are given in Table 1 and the variations of velocity across the cross-section is shown in Fig. 1 in which the ordinates are the square root of the head and the abscissas are the corresponding positions in the duct. From an extrapolation of these curves to a diameter of 12 in. the values in Column 23 of Table 1 are obtained. In arriving at the average square root of the head as tabulated in Column 25, the square root of the head at the extremity of each diameter was given a weight in proportion to the area of the annular ring between the circumferences of circles drawn half-way between the given diameter and the two adjacent diameters. These relative weights were as follows:

Center	0.16
1 in diameter	1.28
2 in. diameter	2.56
3 in. diameter	3.84
4 in. diameter	5.12
5 in. diameter	6.40
6 in. diameter	7.68
7 in. diameter	8.96
8 in. diameter	10.24
9 in. diameter	11.52
10 in. diameter	12.80
11 in. diameter	14.08
12 in. diameter	15.36
Total	100.00

The irregularity in the shape of the curves in Fig. 1 at high velocities is to be charged to the disturbing effect of an elbow in the line. This elbow was eight diameters away from the point at which the pitot-tube readings were taken, but its effect was noticeable at velocities over 2000 ft. per min.

At the same time similar coefficients were computed from some experiments of Prof. C. C. Thomas at the University of Wisconsin and reported by him in a paper "The Measurement of Gases," *Journal* of the Franklin Institute for November, 1911. The primary object of the tests was a comparison of three methods of metering gases: (1) pitot tube; (2) venturi meter; (3) electric meter, but the pitot-tube data, which are given in Table 2, were in sufficient detail to calculate the velocity ratio. In this work pitot-tube readings were taken on one diameter at 1-in. intervals from the center of a 16-in. duct to 5 in. out, and at ½-in. intervals from this point to within ½ in. of the inner surface. The value of the average square root of head was determined by giving a weight to each velocity (square root of velocity head) proportional to the area of the annular ring whose mean diameter was the diameter of the tube circle. This method results in somewhat greater values than those determined by the graphical solution described in the *Journal* of the Franklin Institute, November, 1911.

The variations of the ratios, Average velocity ÷ Center velocity, from both sets of tests is plotted in Fig. 2. The agreement between them is very satisfactory.

It has been suggested that the mean head could be determined by a single tube placed at such a point as to intersect the curves at the mean height. This particular point would be at a distance of 5¼ in. from the center of the 12½-in. duct. There are two serious objections to this method: First, readings on a horizontal and ver-

tical traverse are never the same except at the points nearest the center and it would be impossible to locate the mean point, and, second, the velocity is changing rapidly in this region and the greatest care is necessary in adjusting the tube to this point even if the first difficulty could be overcome. The great advantage of the single central tube with its proper correction factors is brought out by the inspection of the central region of the curve, Fig. 1, which shows clearly that for a ½-in. to either side of the center the velocity head remains practically constant, thereby giving a region in which settings of the central tube may readily be made.

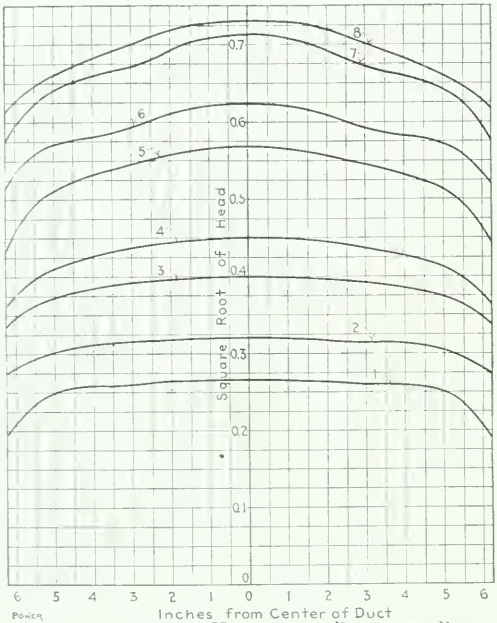


FIG. 1. VARIATIONS IN VELOCITY AT DIFFERENT POINTS ON CROSS-SECTION OF DUCTS

From the plot, Fig. 2, it may be concluded that for ducts from 12 to 16 in. in diameter the ratio, Average velocity ÷ Center velocity, will vary as a linear function of the center velocity from about 0.93 at 1000 ft. per min. to 0.91 at 3500 ft. per min. For smaller ducts the coefficients would probably decrease and for larger ducts a slightly greater value might be expected.

LEO LOEB,
U. S. Naval Engineering Experiment Station.
Annapolis, Md.

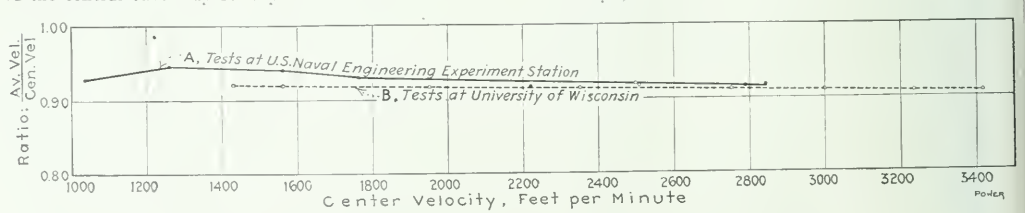

Ratio: Av. Vel. / Cen. Vel.
1.00
0.90
0.80
A, Tests at U.S. Naval Engineering Experiment Station
B, Tests at University of Wisconsin
1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400
Center Velocity, Feet per Minute
POWER

FIG. 2. VARIATIONS OF RATIOS OF AVERAGE TO CENTER VELOCITIES

Water Leaves Boiler

Referring to Mr. Walling's inquiry in the Jan. 21 issue and the discussion on this subject in the Feb. 18 issue, my experience with cast-iron sectional boilers leads me to believe that they are subject to a quickly fluctuating water level, as the amount of water they contain is very small. As soon as steam is being raised, the water will drop quickly unless an automatic feeding device is employed. But, in Mr. Walling's case, I think that the principal fault lies in the small return pipes. He says that he has a single-pipe system. The building is three stories high and the main part has ¾- and 1-in. return pipes, enlarged to 1¼ in. at the boiler, while the wing has a 1¼-in. return pipe all the way. Now there is in all probability one or more radiators on each floor from each riser. This means that the ¾-in. pipe has to take care of the condensation from at least three radiators and perhaps six. Even for three, I believe the ¾-in. pipe is too small. It means that water is taken out of the boiler in the form of steam much faster than the small return pipes will allow the condensation to flow back to it. The smallest return pipe in his system, in my opinion, should be 1¼ in. and at least 2 in. at the boiler, and even that is not so large as I should prefer, a 2½-in. pipe would be better.

As for the hammering, if there are no pockets in his horizontal lines and no leaky radiator valves, he will probably find that it will disappear if his return pipes are enlarged. If he has no automatic feed on his boilers, I should strongly recommend that they be installed. They are inexpensive and easily attached and, if they do keep the water level high during the shutdown over night, that water cannot do any harm and could always be blown down. Of course, if the water is going out through the blowoff, he will have to attend to that; but I take it that he means that the water is in the system but not in the boiler. I think that if Mr. Walling will put in larger return pipes most of his troubles with his system will be over.

W. H. PYATT.

Brooklyn, N. Y.

A one-pipe heating system, somewhat resembling the one described by Mr. Walling, gave trouble in much the same manner. The radiators in the wing of the building would get cold and the water leave the boiler. The water in the boiler would rise and fall with a surging effect. A check valve, opening to the boiler, was placed in the return from the radiators in the wing, and after that no more trouble was experienced.

H. G. GIBSON.

Washington, D. C.

EDITORIALS

The Conditions in Massachusetts

Those who are concerned with the procuring and administration of laws for the examination and licensing of engineers and the inspection of boilers, will be interested in the conditions existing in Massachusetts, where this sort of legislation has reached its highest development, and the law and practice of which have been accepted as models.

When the law was adopted some eighteen years ago, the examiner for whom it provided was made an attaché of the Massachusetts district police and the department, although it has increased to some twenty-five inspectors and examiners, has remained a subdepartment of the state police arm, under the authority of the chief of that department. He has no knowledge of engineering, and its members, supposedly versed in all that pertains to the safe construction, installation and use of boilers, engines and power-plant apparatus but totally lacking in police training, are a part of the armed and uniformed force, although they wear their uniforms only upon state occasions and are subject to call only for the suppression of riot, etc.

Subsequent legislation provided for a Board of Boiler Rules, of which the chief inspector of the boiler-inspection department should be chairman and which should be further composed of one member representing the boiler-using interests, one the manufacturing interests, one the boiler-insurance interests and one member who is an operating engineer. These four members are appointed by the governor and do not come under the jurisdiction of the chief of the district police.

In July of last year, the chief of the boiler-inspection department resigned. There had been, in the meantime, a movement afoot in which some of the examiners had been active to divorce the department from its police affiliations. This "pernicious activity" had rendered them *personae non gratae* to the chief of the district police, who sought the advice of the attorney general as to whether the civil-service requirement, governing the appointment of the chief inspector by the governor, still held; for these perniciously active examiners had come out of the previous examination with high ratings. The attorney general found that the necessity of appointing a successor to the chief had never occurred to the "general court"; that no provision was made for such appointment. The governor could not fill the office without warrant of law, because the treasurer's department would fail to find any authority for the emolument. The legal adviser, however, suggested that the chief of the district police had the power to appoint an acting chief who might serve without increase of pay until the legislature could repair the remissions of its predecessor.

This was done, but the Board of Boiler Rules, appointed by his excellency direct, owing no allegiance to the police department, refused to accept his appointee as their chairman and requested the governor to subject candidates for the position to a civil-service examination.

To the civil-service examination came seven of the nineteen inspectors of the department. Perhaps, the others did not want to get mixed up in a strife between superiors; perhaps, they were deterred by other considerations. Of the seven who went in only three got above the sixty-five per cent. necessary to qualify and the chief's repudiated appointee got only fifty-four. The perniciously active came off, we understand, with the highest percentages. But what does that avail when a man has so little sense of discipline and decorum as to go about calling his chief names? The questions asked at the examination are printed on page 292 and are puerile compared with those which some of the examiners are alleged to have proposed to the ordinary garden variety of engineer who appeared before them for examination.

And, so the matter stands. The chief will not withdraw his appointment; the Board of Boiler Rules will not accept him and his excellency says, "Let the general court do it."

We dislike to see the Massachusetts law, or anything connected with its administration, come into ridicule or disrepute. It is an excellent law and we should like to see other states adopt it instead of getting up a variety of dissimilar statutes. Coöperation between the boards of rules appointed under such laws would result in uniformity of practice and the avoidance of different standards for different states. Such inspection is really an exercise of the police power of the state; but so are factory inspection and the activities of the board of health. There seems to be no good reason for linking it up with the criminological branch and making the chief inspector responsible to a police official, on one hand, and subject to the Board of Boiler Rules, on the other.

This mistake may be avoided by other states which adopt the law. Another possible good which may come out of the situation is the realization by some of the inspectors of the ridiculousness of some of the examinations which they give, as indicated by the questions, which are often sent to us as having been asked by Massachusetts examiners, and which lead to the rejection of such men as W. E. Crane, who first applied the double eccentric to a Corliss engine, and failed to satisfy the inspector that he knew enough about its setting and effect to be entrusted with a license to run one.

Internal Combustion Engine for Central Stations

While with low load factors and cheap fuel, the steam turbine in large units is the only form of heat engine to be considered for central station work, there may be cases where a combination of high load factor and expensive fuel restores the advantage to the internal combustion engine. This is stated by M. Gercke, chief engineer of the Maschinenbaufabrik, Augsburg-Nürnberg, in a paper prepresented to the Central Station Association at Keil recently, an abstract of which will be found on page 286

There are several stations, he says, in Germany in which Diesel engines and steam turbines are installed together, the engines taking care of the steady load, the turbine of the peaks.

The question suggests itself whether there may not be numerous instances in metropolitan practice where the location of a large internal combustion station in the heart of the system might be advisable. Such a station composed of only enough units, of the greatest capacity available, to take care of the continuous load, would generate current very cheaply, running as it would practically continuously at its rated capacity. The location of the plant in the center of this district to be served would reduce the amount of copper required and whether producers or oil engines were used, there would be freedom from the smoke nuisance, so important in a crowded locality.

It is not beyond the bounds of practicability that the problem of cooling water could be solved by utilizing the waste heat of such a station, in a heating system for the surrounding buildings. The situation of the station in a densely occupied district, would again conduce to this result and the ability to furnish heat as well as current would extend the range of application for the central station service. An economical turbine station on the water front could furnish, through smaller mains than would be otherwise necessary, the surplus current required for the peaks.

The most extensive use for large gas engine plants has been in connection with iron and steel works where gas is practically a byproduct and where the comparatively high price and cumbersomeness of the gas engine counts for most as against the burning of this gas under boilers and the utilization of the steam in the simpler and less expensive turbine. May we not see a revival of the large gas engine installation, under conditions which will offer it a better chance?

New York Boiler Laws

Is New York State to have a boiler-inspection law? Those who listened to the remarks of the speakers at the recent dinner of the American Institute of Steam Boiler Inspectors could not help but feel optimistic in the matter. However, this is not the first time, by any means, that boiler-inspection laws have been proposed for New York. Several times the prospects have seemed particularly bright for the adoption of such laws when opposition was encountered, influential enough through legislative channels, to defeat them.

As to the desirability of a state inspection law, little need be said—its merits are obvious. In fact, they are so overwhelming that its opponents dare not come out in the open. Any opposition that may develop is likely to spring from certain interests in cities within the state, which have their own boiler regulations. Boiler inspection in New York City has long been recognized as deficient. Not that the inspectors are incompetent, but they are laboring under a system which prevents them from doing full justice to their work. It is time for a change from these conditions.

Equally as important as the construction and inspection of a steam boiler is its operation. The best boiler in the hands of an incompetent man is more dangerous than a stick of dynamite. This leads to the consideration of a state license law. One without the other affords only partial protection. In Massachusetts, an engineers' and firemen's license law, a boiler-inspection law and rules governing the construction of boilers are enforced conjunctively. One other state, Ohio, and several cities, have adopted the Massachusetts law as a whole, while other states and cities have adopted it in a modified form, or certain of its provisions. The Massachusetts rules are regarded as the standard, and New York, which boasts of being the Empire State, cannot afford to compromise but should adopt the best there is.

The present movement has the advantage over previous ones in that it is being pushed by the American Institute of Steam Boiler Inspectors, whose judgment in such matters should carry much weight. Furthermore, it has the support of many prominent boiler manufacturers and insurance companies and will no doubt be heartily indorsed by all engineering societies within the state.

May success be the reward of this latest effort.

No More Merchant Pipe

Standard pipe is a good deal thicker, and hence stronger than it need be for many purposes, especially in the smaller diameters. It has been the practice to draw pipe, to order, of less than the standard thickness for use under conditions in which the standard pipe was not necessary, and this pipe, of the same outside diameter as the standard, threaded and coupled like it, similar in every particular except in thickness and weight, has been known as "merchant" pipe.

The reduction in weight per running foot has been kept within limits and the merchant pipe subjected to the same test, seven or eight hundred pounds per square inch, as the standard pipe. So long as the purchaser knew what he was getting and used it intelligently no harm was done, and unnecessary expenditure was avoided.

But with a lot of pipe of less than standard thickness floating around, all looking alike, all threaded alike, only the expert, or he who was particular enough to weigh or gage it, could be certain that he was getting what he paid for, and this thin pipe was likely to be inadvertently perverted to uses for which it was not adapted.

The National Tube Co., therefore, has announced, and we understand that most if not all of the other pipe producers are adopting the same attitude, that it will draw no more merchant pipe, so that when a man buys a length of pipe he may be sure that it is within five per cent. of the prescribed weight above or below. It may look arbitrary to refuse to draw an order of pipe of special thickness (or thinness) for a customer who has use for a large quantity for gas or other low-pressure service, but in clearing the market of undersized stock and making "standard pipe" mean one thing, the move is the best thing which has happened for the purchaser of piping in many years.

According to one engineer the extortionate prices imposed by the coal barons are not undiluted evil. "I wish the stuff cost twice as much," he says, "then a man would get a little more credit for saving it."

READERS WITH SOMETHING TO SAY

Interesting Piping Problem

In power-plant design the end which suffers most from lack of careful study is usually the piping. Much of the piping is often left until the last moment after the position of all the various pieces of apparatus has been decided upon, and is rushed through without much thought as to system or cost. I recently had brought to my attention a piping layout in which a saving of several hundred dollars over the original method was effected by a careful study of the whole problem and a revision of the plans.

Referring to the diagram, A is the power plant and it is desired to carry steam to the point D. BD is a tunnel

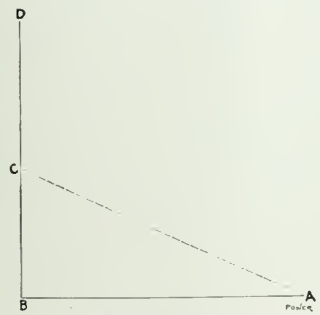


Diagram of Pipeline

in which the pipe is carried on hangers. From A to BD it is necessary to run the pipe in conduit. The original layout was to run the pipe through a conduit to B (ABD being a 90-deg. angle) and then through the tunnel to D. Estimates were secured for installing the pipe in the conduit at $7 a foot and in the tunnel at $3 a foot. If run the way originally intended the cost would be $10,000. If run from A to D in a straight line through a conduit the cost would be $9900. From a study of the layout it was evident that by running the conduit to some point C, intermediate between B and D, the work could be done for the least money. The problem, therefore, was to locate C. This can be done by the use of trigonometry and a trial and error method, but is long and tedious. A much simpler method is the use of what is known as "maxima and minima" in differential calculus.

If we call the distance

$AB = a$;

$BC = x$;

and

m = Cost per foot for a;

n = Cost per foot for x;

then without giving the various steps by which the result is obtained

$$x = \frac{an}{\sqrt{m^2 - n^2}}$$

For the case given BC should be 475 ft. This gives a total cost of $9325.

If there was a pipe going from C the other direction in the tunnel and its cost was z the equation would be

$$x = \left(\frac{n - z}{\sqrt{m^2 - (n - z)^2}}\right) a$$

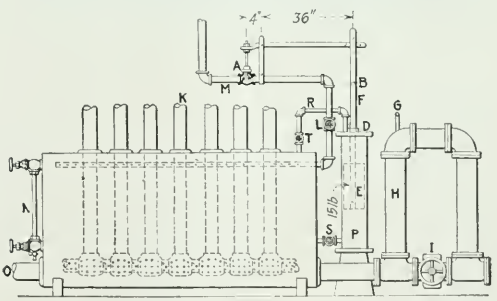
W. L. Durand.

Brooklyn, N. Y.

Receiver and Automatic Control

In the plant where I am employed, a tank 5 ft. in diameter and 12 ft. long receives the exhaust and returns from five engines and two paper machines. The boiler-feed pumps remove the water. Make-up water was always regulated by hand and it was impossible to keep the water level at a normal height; there was also a great variation in the temperature.

A number of float arrangements had been tried to automatically regulate the make-up water, but without success. I tried the device illustrated herewith, which worked satisfactorily. A is a common globe valve with a smooth stem. B is a ball joint. At first we used a piece of 8-in. pipe for the float chamber P, with the top open to the atmosphere, but at times the water in the receiver would get above 212 deg. F. and, owing to the small area of the atmospheric pipe K, the pressure would rise from 1 to 5 lb. pressure, which forced the water in the receiver, up into the float chamber, closing the valve at the time it should be open.



Piping of the Return Tank and Automatic Control

To overcome this we put a cap on the top end of the chamber P with a packing gland at D for the float rod to run through, and connected a pipe R to the top of the receiver and float chamber to equalize the pressure.

A piece of ⅜-in. nickel-plated pipe F was used for the rod. It was soldered to the bottom and top of the float and a ⅛-in. hole drilled at E and another below it. This overcame the trouble encountered from collapsing floats.

There is 25 lb. pressure in the pipe M. Valves S and T

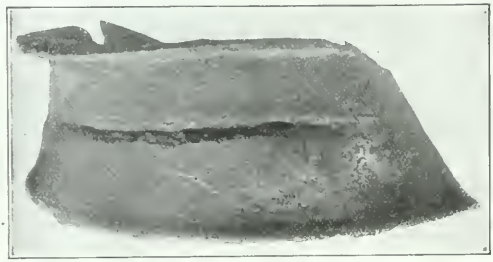
are to shut off the float chamber, *H* is the overflow; *G* is a vent to prevent siphon action; *I* is the blowoff valve; *L* is a valve to be used if the float is out of commission, *N* is a gage-glass; *O* the pump suction, and return pipes are shown on top of the tank.

R. A. Hafford.

Groveton, N. H.

Corroded Boiler Tubes

The boiler tube from which the accompanying illustration was made was lately removed from a horizontal return-tubular boiler, near Detroit, Mich. This boiler is using water containing a considerable quantity of sulphates. The scale is not generally thick nor hard. Raw water, in the winter only, makes up about 50 per cent. of the feed water, the remaining 50 per cent. is condensation from the heating system, which is returned to the boiler by a return trap.



Corroded and Cracked Boiler Tube

Natural gas is used for fuel, together with refuse, consisting principally of wood.

Cutting of the tubes by corrosion on the exterior of the tube occurs close to the inside of the front head. These tubes are from three to about 10 years old. The faulty ones are not all close to one another but scattered about the nest. Other boilers belonging to the same firm, located across the street, have not experienced any such trouble in over ten years.

We fail to find any good reason for the cause of this trouble and thought that perhaps some reader might have had a similar experience. Comments by those who can throw light on the matter will no doubt prove of general interest to engineers and firemen.

J. B. Latour.

Toronto, Ont., Can.

Calculating Scales

The calculating scale, Fig. 1, is for horsepower computations; Fig. 2 is for figuring pipe areas for the flow of steam under different conditions of pressure and velocity. The horsepower calculator is used in checking the horsepower of engines, but the limits are so large that extreme accuracy is not attainable with the size of scale used.

The steam-flow scale is of value for anyone interested in the design or operation of steam machinery. With larger subdivisions the error of about 2 per cent. would be decreased.

Referring to Fig. 1, assume that the horsepower of a 14x24-in. engine is to be found, having a mean effective pressure of 52.5 lb. and a speed of 150 r.p.m. Place the stroke scale *C* opposite the mean effective pressure scale *B*

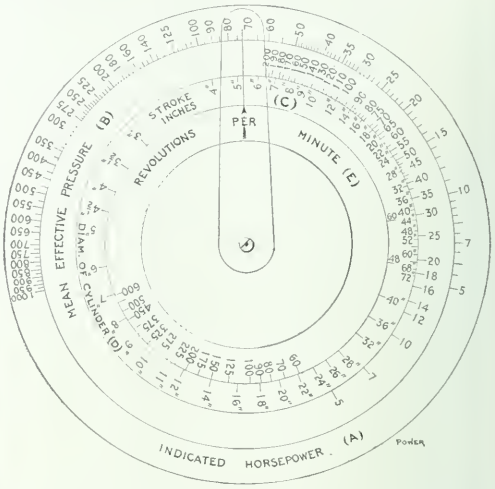


Fig. 1. Chart for Computing Engine Horsepower

and revolve the top disk until the revolution per minute scale *E* is opposite the cylinder-diameter scale *D*. Then revolve the rider arm to the arrow and read the horsepower on the scale *A*. Thus 24 and 52.5 will line up on the scales *C* and *B* and 150 and 14 will line up on scales

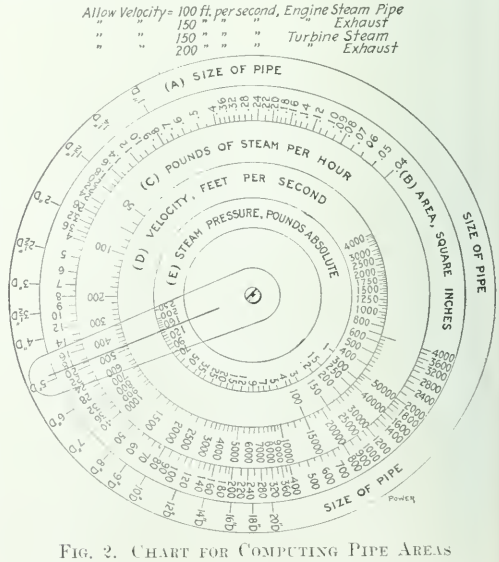

Allow Velocity= 100 ft. per second, Engine Steam Pipe Exhaust
" " 150 " " " "
" " 150 " " " Turbine Steam Exhaust
" " 200 " " " "
(A) SIZE OF PIPE
(C) POUNDS OF STEAM PER HOUR
(B) AREA, SQUARE INCHES
(D) VELOCITY, FEET PER SECOND
(E) STEAM PRESSURE, POUNDS ABSOLUTE
SIZE OF PIPE
SIZE OF PIPE
Power

Fig. 2. Chart for Computing Pipe Areas

E and *D*. The line on the rider, when covering the arrow, points to 72.5 hp., or double that for the total horsepower developed per revolution, 145 hp.

The chart shown in Fig. 2 is manipulated similarly. Assume the steam velocity is to be 100 ft. per sec., steam

pressure 150 lb. and that 15,000 lb. of steam is required per hour. Place the velocity scale *D* opposite the desired quantity of steam on chart *C* and move the rider over the steam pressure sidewise on scale *E*, the area will be shown as 18 sq.in. on the scale *B*.

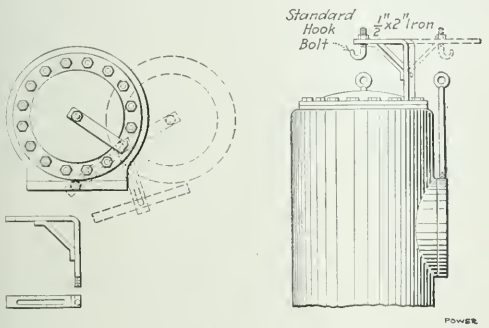
G. H. Bascome.

Elmira, N. Y.

Device for Removing Pump Cylinder Heads

The device illustrated herewith I find very handy for removing water-cylinder heads on horizontal pumping engines where the crane service is available.

The only provisions necessary for applying it are an eye-bolt hole drilled and tapped in each head and the sub-



Device for Removing Cylinder Heads

stitution of a tap bolt for a stud in the holes where the bracket leg screws in. The slotted oblong hole in the bracket, facilitates removing the lower side heads which may be handled either by a long hook bolt or the same hook bolt and a long eye-bolt, preferably the latter, as shown.

This makes a portable outfit for this kind of work, and its removal after using leaves the appearance of the pump unchanged, there is no necessity to hang unsightly timbers, ropes, hoists, etc., overhead.

W. Oliver.

Racine, Wis.

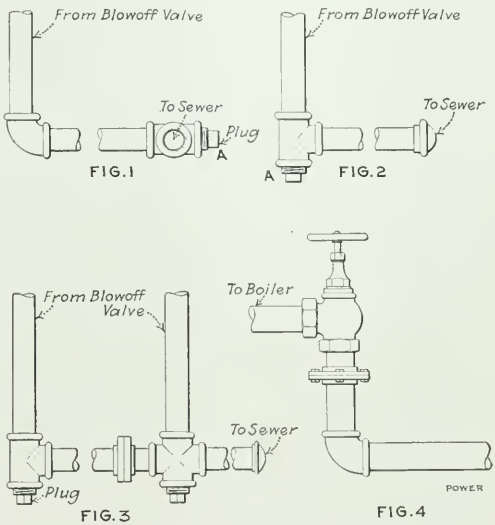
Openings to Detect Leaky Blowoff Valves

It is good practice to have an opening in the blowoff pipe between the blowoff valve and where the water is discharged, as then one can see at once if the blowoff valve is leaking or not.

Especially should this be done where the water is discharged into a closed tank or catch basin. Our blowoff pipe discharges the water into a catch basin outside of the building and the blowoff pipe is arranged as shown in Fig. 1. After I start filling the boiler with water the plug *A* is removed and the end of the tee left open until steam is raised in the boiler. In this way, if the blowoff valve leaks ever so little, it can be detected at once. I also find this affords a good means to make sure that the blowoff valve is not leaking after blowing some of the dirty water out of the boiler in the morning or during the noon hour.

Where there is room the tee could be placed next to the blowoff valve, as shown in Fig. 2, and where the blowoff pipe of two or more boilers discharges into one main trunk pipe leading to a closed tank or catch basin, the piping could be arranged as shown in Fig. 3.

One bad mistake some engineers and steam fitters make in connecting a blowoff valve to a boiler is that they fail to place a flange or union near the valve between it and where the water is discharged. Often the flange or union is placed a long distance from the valve, then, if it is necessary to take out the valve for repairs or to re-



Blowoff-pipe Connections Arranged to Indicate Leaky Valve

place it, a lot of piping must be disconnected, causing unnecessary labor and expense. All this trouble can be avoided by placing the flange or union as near as possible to the blowoff valve.

H. A. Jahnke.

Milwaukee, Wis.

Engine Vibration Tests

In the advertisement of the Rollins engine in a recent issue of Power I read that a Massachusetts engineer balanced a pencil on the top of the cylinder and it stood upright all day.

This certainly speaks highly for the engine, but I once performed a little experiment myself which I thought rather hard to beat. While running one of those 125-hp. engines installed in the F. B. Pierce Chair company's shop at South Keene, N. H., I balanced three ten-cent pieces on various parts of the engine, one on the pillow block, one on top of the cylinder over the back head, and one on the frame over the girder, and they would stand that way for hours or until I got short of spare change.

Arthur H. Parker.

Warren Summit, N. H.

QUESTIONS BEFORE THE HOUSE

Air Receiver Explosions

Some months ago, while investigating the causes of an explosion of an air receiver that was carrying 100 lb. gage pressure regularly, I found and reported that the inside of the receiver was coated with grease to the extent of ¼ in. thick or more. Since that time, I have had opportunity to examine four other compressors and receivers. In each case the interior of the shell was coated with grease from ¼ to ½ in. thick. I immediately began to look into the lubrication of the compressor cylinders and have since been watching the lubrication of various running compressors, with the following deductions, some of which agree with the previous discussion on this subject:

Many mines employ a man to run the compressor and, at the same time, watch the hoist located near-by. This man must set his lubricator to feed the oil and, nine times out of ten, adjusts it to feed about the same as for a steam cylinder. Frequently he starts it cold and after running it awhile goes back and finds a tiny stream of oil running into the cylinder. Again, when the lubricator is empty, he grabs an oil can, as he gets a hoisting signal, and rushes over to put a few drops into the lubricator before answering the signal. A change in engineers frequently means a change in oils and a different rate of feed. Even if the engineer has only the compressors to care for he is generally a "steam-man" and gages his steam and air-cylinder lubrication alike.

Frequently incompetents are entrusted with motor-driven compressors, and are instructed to watch for hot bearings, pull the switch if anything goes wrong and send for the electrician. All that such men can do is to pour out oil, which they generally do.

Many compressors draw their air from the hot engine room and out here on the desert of Nevada, the mine compressors frequently have open unfiltered intakes drawing in desert air with a goodly portion of dust and alkali. Assuming this intake temperature to range from 120 to 160 deg. F. and the compression from 100 to 104 lb. gage pressure, the heat of compression may run up the temperature to 500 deg., which is higher than the flash point of many cylinder oils. The stopping of the discharge by a valve stem sticking, or grease or carbon accumulating to reduce its area, or by running the compressor at overspeed, may cause some of the heated air to come back for recompression and still further advance the temperature. Cylinder jackets might help some, but the use of muddy mine water without any attention would soon reduce their value.

Many steam-driven compressors have throttle governors to reduce the speed when occasion requires, but, in several cases, I have observed that the lubricator was left adjusted for the maximum speed.

To avoid air-receiver explosions, it would seem that several points can be emphasized. Use only the best of compressor oil and use only as little of it as possible, far less than any steam cylinder requires. At the lowest point of the receiver tap for a drain and screw in a short nipple. Then bush the out end of the nipple up to a 3- or 4-in. pipe and put on a piece 6 in. to 1 ft. long. Reduce again to the size of the stop cock valve it is desired to use. This forms a pocket or trap for the moisture and oil, which can be readily blown out. In the absence of a trap, a hole is blown in the residue when the blow-off cock is opened. The little hole immediately fills up and the thick oil deposit does not flow at all. I have seen soft soap and water and potassium or sodium hydrate and water used for cleaning grease and gum from cylinders, air passages and receivers with considerable success. Gasoline, kerosene, naphtha or the like should not be used as they are likely to form highly explosive gases inside the air passages. In any event, a manhole should be provided in the receiver so that it can be readily scraped and cleaned.

Tonopah, Nev. LETSON BALLIET.

Mr. Booth's Condenser Problem

The problem given by W. H. Booth in the Dec. 17 issue relative to the source of power that lifts the cooling water into a jet condenser 17 ft. above a canal, proves to be of unusual interest.

By his wording, I assume that the question means that the outlet from the air pump is open to the atmosphere 17 ft. above the canal, and that from there the water runs down freely through an open pipe or duct to the canal. This assumption being correct the answer to the question is that the lifting power comes directly from the air pump.

Let us imagine a theoretical case of a plant of, say 500 hp., where there are 175 lb. of steam condensed per minute, assuming a ratio of cooling water and steam of 30 to 1. The cooling water would amount to

$$30 \times 175 = 5250 \text{ lb. per min.}$$

Adding this to the 175 lb. of condensate gives 5425 lb. of water pumped out by the air pump per minute. To make the problem simple, assume there is no air in either the condensed steam, or in the cooling water and that the wet-air pump handles a full cylinder of water every stroke. Assuming, also, that the hotwell temperature is 115 deg. F., the water handled by the wet-air pump would weigh 61.8 lb. per cu.ft. Then we have

$$\frac{5425}{61.8} = 87.8 \text{ cu.ft.}$$

of water pumped per minute.

Further, let the vacuum be about 26 in., giving an absolute condenser pressure of 2 lb. per sq.in. Then the head against which the wet-air pump must discharge is

$$14.7 - 2 = 12.7 \text{ lb. per sq.in.}$$

Neglecting slippage, friction and all other losses, the power developed in the water cylinder of the air pump would be

$$\frac{87.8 \times 12.7 \times 144}{33{,}000} = 4.86 \text{ hp.}$$

Of this amount, the cooling water represents

$$\frac{5250}{5425} \times 4.86 = 4.71 \ hp.$$

Now, supposing a purely theoretical (and really impossible) condition, that the cooling water is as hot as the hotwell water just to have one horsepower balance theoretically the height to which the available vacuum would lift the cooling water. This would be

$$\frac{12.7 \times 144}{61.8} = 29.6 \ ft.$$

To lift 5250 lb. of cooling water per minute through 29.6 ft., would require

$$\frac{5250 \times 29.6}{33{,}000} = 4.71 \ hp.$$

Thus we see that the power exerted by the suction of the condenser (the atmosphere) is exactly the same as that developed in the wet-air pump, pumping the cooling water only from vacuum to atmosphere. Thus, the power to lift the cooling water comes from the pump.

As a matter of fact, the theoretical condition that the cooling water is as hot as the hotwell water is impossible; so assuming the cooling water at 60 deg. F., it would weigh 62.4 lb. per cu.ft., and the actual column that the vacuum would support would be

$$\frac{12.7 \times 144}{62.4} = 29.3 \ ft.$$

and the horsepower necessary to lift this column of water would be

$$\frac{5250 \times 29.3}{33{,}000} = 4.66 \ hp.$$

The difference between this and the 4.71 hp. or 0.05 hp. is the little extra burden that the air pump has to bear, due to the heat put into the water with its consequent expansion.

Suppose we have a surface condenser. Without any air, the air pump would develop only the power required to pump the 175 lb. of condensed steam per minute. This would represent a volume of

$$\frac{175}{61.8} = 2.83 \ cu.ft.$$

which against 12.7 lb. pressure would be

$$\frac{2.83 \times 12.7 \times 144}{33{,}000} = 0.157 \ hp.$$

If there were any lift, there probably would be an equal drop at the outlet; so, except for friction, the circulating pump requires no power at all.

If we have a barometric condenser, without any air pump, the condenser could, theoretically, be placed a distance above the hotwell equal to the height of condensate that the atmosphere will support. This we have already figured to be 29.6 ft. If the cooling water were at the same temperature, this too would be lifted this height by the vacuum (atmosphere) and once started would continue round and round, assuming no friction, without any pumping. However, the cooling water to be of any use must be cold, so assuming 60 deg. as before, the height to which the vacuum would lift this water would be, as already figured, 29.3 ft. The extra lift of 0.3 ft. must be supplied by a circulating pump, as well as considerably more lift necessary to insure that the condensing chamber shall be high enough above the hotwell to free itself quickly of water. This usually is not less than 34 ft. total.

Applying these theoretical considerations to Mr. Booth's problem, we find the lift in his case is only 17 ft., which is much less than the head against which the pump must discharge. The rest of the available column must be absorbed by water friction, or a throttling valve, which is the same thing, so the air pump is really lifting all the cooling water into the condenser and overcoming this friction also. The friction does not throw any more load on the air pump because the pump must develop the full power in getting the cooling water out against the atmosphere and this may be absorbed entirely by lifts or by a shorter lift with more friction. The power is there; so, within lifting range, the height of lift does not really alter the power.

It is perfectly possible to decrease this power by properly piping the condenser outlet back to the canal level. This would then form a siphon and, barring friction and air and the change in volume, due to water temperature, no power would be required to circulate the cooling water. The atmosphere would raise the water against gravity and gravity would return it against the atmosphere. In this case, any power obtained from a water turbine in the return to the canal, as Mr. Booth mentioned, would come from the air pump itself.

If a jet condenser is placed on a level with the source of cooling water supply, the air pump must do the entire work of pumping out against the atmosphere. This is because, there being no lift, the cooling water must be choked back by a valve, lest it swamp the condenser and run back into the engine; and there being no lift there can be no drop on the discharge, so gravity cannot help to remove the water. If, however, the condenser can be elevated so as to use the vacuum to elevate the water and the rest of the vacuum to overcome friction and valve control, the consequent drop at the discharge, less its friction, will be almost enough to get the cooling water up into the condenser. Then the air pump, aside from handling the condensate, need overcome only friction in removing the cooling water. By the elevation the vacuum overcomes gravity, which can return the work, instead of valve friction, which cannot return anything. Some provision might have to be made to get the air down the discharge pipe, but a high-water velocity would probably carry away all the air contained in the column of water.

This brings us to the conclusion that, properly arranged, neglecting friction and air, no kind of condenser should require power to handle cooling water except that to overcome the effect of a slight expansion of the water, due to an increase of temperature. Thus expansion would tend to make the siphon run backward and this tendency must be overcome with a pump. Even in a barometric condenser, where the work seems to be done by gravity, the energy of the steam must be used to lift the steam itself up into the condenser (so many pounds' weight against so many feet lift) for it to run out again by gravity against the pressure of the atmosphere. If the engines are above the condenser, then this lifting is done between the boilers and the engine; or if the boilers too are above, the work is done by the boiler-feed pumps.

R. S. Bayard.

New York City.

INQUIRIES OF GENERAL INTEREST

Grate Area—What should be the grate area of a 200-hp. boiler?

M. P. M.

A 200-hp. boiler should be capable of evaporating.

$$200 \times 34\tfrac{1}{2} = 6900 \text{ lb. of water per hr.}$$

from and at 212 deg. F. at atmospheric pressure. For ordinary good operation 9 lb. of water should be evaporated per pound of coal. Then the coal required per hour is

$$\frac{6900}{9} = 766.6$$

Average practice allows 18½ lb. of coal per hour per square foot of grate. Then

$$\frac{766.6}{18.5} = 41.4 \text{ sq.ft.}$$

or, in round numbers, 42 sq.ft. should be the grate area.

Sliding Foot on Engine—Why does a Rice & Sargent engine have a sliding foot?

S. J.

A sliding foot is placed under the engine to permit the frame to assume its natural alignment without being strained, as it might be, from expansion and contraction, or springing of the engine bed.

Greatest Pressure in a Boiler—What part of a B. & W. boiler is subject to the greatest pressure?

F. F. M.

The greatest pressure per unit of area comes on any boiler at the lowest point that is subjected to the hydrostatic pressure of the water in the boiler. In a B. & W boiler, that point would be the mud drum.

Oil Engine Cylinder Oil—What is a suitable cylinder oil for oil engines of the semi-Diesel type?

J. L. L.

A light, clean mineral oil should be used, having a flash point of at least 370 deg. F. and a specific gravity of from 0.913 to 0.907 or 24 to 25 deg. on the Baumé scale.

Boiler Circulating Pipes—Where is the circulating pipe attached in a vertical shell steam boiler and what is its particular function?

J. S.

Circulating pipes are sometimes placed in vertical boilers connecting the water space above the fire-tube sheet to the lower part of the water leg, to induce a rapid circulation in the water leg to prevent mud and sediment accumulating there.

Furnace Draft Velocity—How can the velocity of the draft in a boiler furnace can be calculated from the force of the draft?

J. B.

The force of the draft cannot be converted into the velocity of the draft, because the obstructions offered by the grate and fuel bed and the friction of the air through the passages cannot be told. The velocity of the draft can be ascertained by placing an anemometer in the air entrance or draft passages in the flues.

Concrete Boiler Setting—Is concrete a satisfactory material for a boiler setting or can it be made so by lining with fire brick?

J. G. B.

Brick is better for the side walls of a boiler setting than concrete, even when the latter is lined with fire brick and an air space is left, because expansion of the concrete would be inevitable and the walls would be very likely to crack in such a way as to be weakened and to admit air through the crevices formed, and this would be seriously detrimental to the boiler economy.

Boiler Horsepower—What is meant by the equivalent evaporation of a boiler and how is the boiler horsepower rated?

W. N. M.

The equivalent evaporation is the number of pounds of water that would be converted into steam at 212 deg. F. and atmospheric pressure by the same amount of heat that was utilized in the actual evaporation; i.e., the weight of water converted into steam at the pressure and temperature obtaining. A boiler horsepower is usually rated as each 34½ lb. of equivalent evaporation per hour.

Hydraulic Elevators—Explain the principles of "Standard Plunger" and high-speed hydraulic elevators. What is the cycle of operation? Can the same water be used indefinitely in the operation? Is the use of air necessary?

C. R.

Standard Plunger and other high-speed hydraulic elevators are operated by the pressure of water maintained in an accumulator or in an elevated tank. When the water is discharged from the elevator cylinder, it escapes to a discharge tank and is pumped to the accumulator, either against a confined cushion of air or against a loaded plunger, or to an elevated supply tank. The accumulator is filled automatically by a pump controlled by a governor. The water is used over and over.

Pressure on Pump Suction—Will a plunger pump work satisfactorily if it receives its water under pressure, as from another pump placed lower to help the first take water from a deep well?

P. H. W.

For a plunger pump to work satisfactorily, when there is a pressure head on its suction, its valves must have strong enough springs to close them against the pressure during the discharge stroke, and even then there may be some slipping of the pump. When one pump delivers to another, there should be some kind of an expansion chamber between them, unless both operate at exactly the same rate or there is opportunity for the initial pump to slip, as a centrifugal pump would, if the second pump failed to take the water fast enough. If the first pump does not deliver the water fast enough, the second pump must slip. The best means of equilizing is to have the first pump deliver into a standpipe to which the suction of the second pump is connected.

Boiler Heating Surface—What will be the heating surface of a Manning boiler 74 in. in diameter, with 284 two-and-one-half-inch tubes 15 ft. long and a firebox 84 in. in diameter by 55 in. high from the top of the grate to the tube sheets?

F. C. C.

Tube heating surface is usually calculated as the area corresponding to the nominal exterior diameter. The circumference of a circle of 2½ in. diameter being 7.854 in., the total heating surface in the tubes is

$$\frac{7.854}{12} \times 15 \times 284 = 2788.17 \text{ sq.ft.}$$

The firebox flue sheet being 84 in. in diameter, its gross area is

$$\frac{84 \times 84 \times 0.7854}{144} = 38.48 \text{ sq.ft.}$$

A 2½-in. tube has a cross-sectional area of 4.9087 sq.in., and the area to be deducted for the tubes is

$$\frac{4.9087}{144} \times 284 = 9.68 \text{ sq.ft.}$$

leaving as the net flue sheet area

$$38.48 - 9.68 = 28.8 \text{ sq.ft.}$$

The diameter of the furnace being 84 in., its circumference is

$$\frac{84 \times 3.1416}{12} = 21.99 \text{ ft.}$$

The height of the furnace being 55 in., the area of the sides of the firebox (neglecting the fire-door opening) is

$$21.99 \times \frac{55}{12} = 100.79 \text{ sq.ft.}$$

The total heating surface in the firebox, therefore, is

$$28.8 + 100.79 = 129.59 \text{ sq.ft.,}$$

and the total in firebox and tubes,

$$2788.17 \times 129.59 = 2917.76 \text{ sq.ft.}$$

ENGINEERS' STUDY COURSE

Mensuration—Part IV
The Circle

If you cut out a carboard disk, 1 in. in diameter, mark a point on the edge, and, placing this point downward on a sheet of paper, roll the disk until the point marked again touches the paper, you will find that the distance passed over, or the circumference, is very nearly $3\frac{1}{7}$ in., or, reduced to decimals, 3.1416 in. This number is not wholly correct, however, as it would never come out even as a decimal.*

Take a circle, 3 in. in diameter, the circumference will be 9.4248 in. The ratio will be

$$9.4248 : 3 = \frac{9.4248}{3} = 3.1416$$

This is true of any circle, so we have the rules. To find the circumference when the diameter is known:

Rule: *Multiply the diameter by 3.1416.*

To find the diameter when the circumference is known:

Rule: *Divide the circumference by 3.1416.*

Example: A flywheel 8 ft. in diameter makes 175 r.p.m. What is the rim velocity in feet per minute?

$$3.1416 \times 8 \times 175 = 4398.24 \text{ ft.} \quad \text{Ans.}$$

Example: The drivers of a locomotive are 60 in. in diameter. If they made 3200 revolutions in traveling eight miles, what was the distance lost due to slippage? 5280 ft. equals one mile.

$$5 \text{ ft.} \times 3.1416 \times 3200 = 50{,}265.6 \text{ ft.}$$

in 3200 revolutions.

$$\frac{50{,}265.6 - (5280 \times 8)}{5280} = 1.52 \text{ miles.} \quad \text{Ans.}$$

Numerous experiments have shown that each square foot of bare iron pipe surface will radiate 3 B.t.u. per hr. for each degree difference between the temperatures of the pipe and the air surrounding the pipe.

Example: What would be the loss in B.t.u. per annum, in the following lengths and sizes of pipes: 200 ft. 2 in.; 66 ft. 6 in.; 162 ft. 4 in.; 20 ft. 12 in.? Steam at 150 lb. gage (366.5 deg. F.) is in these pipes 24 hr. per day, 300 days per year. The average temperature of the air is 80 deg. F. The actual external diameters of the pipes are as follows: 2 in., 2.37 in.; 4 in., 4.5 in.; 6 in., 6.62 in.; 12 in., 12.75 in.

The writer gets 3,066,971,040 B.t.u. for an answer. Is this correct?

Areas of Circles

Let us see how the rule for finding the area of a circle is established:

Let Fig. 1 represent a circular piece of cardboard, the lower half ABC cut into eight equal pieces or sectors, and spread out, as shown at Fig. 2. It is obvious that the length ABC, Fig. 2, equals ABC, Fig. 1, or half the circumference of the cardboard and the height or altitude of the sectors will equal the radius of the circle. If the upper half of the circle be cut into eight equal sectors, they will fit into the spaces formed by the sectors from the lower half, and we will have a nearly perfect rectangle, the area of which would be the same as that of the circle. The greater the number of sectors, the more perfect would be the rectangle formed.

As the length of the rectangle formed will equal one-half the circumference, and the width will equal the radius of the circle, we have the following rule for finding the area of a circle.

Rule: *Multiply one-half the circumference by the radius.*

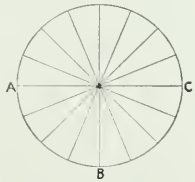


Fig. 1

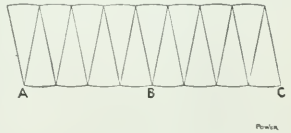


Fig. 2

Expressed as an equation,

$$Area = \frac{3.1416 \times D}{2} \times r$$

but, since the diameter is twice the radius, or $\frac{D}{2} = r$

$$Area = 3.1416\ r^2$$

So the rule might also be given.

Rule: *Square the radius and multiply by 3.1416.*

or

Rule: *Square the diameter and multiply by 0.7854.*

The figure 0.7854 is obtained by dividing 3.1416 by 4. The reason for dividing by 4 is evident from the last equation, where $\frac{D}{2}$ must be substituted for r if the area is to be determined from the diameter instead of the radius. Making the substitution

$$Area = 3.1416 \left(\frac{D}{2}\right)^2 = \frac{3.1416 \times D^2}{4} = 0.7854\ D^2$$

A graphical explanation may be given based on the fact that the line which bounds a square is to the line which bounds a circle of the same diameter as the square, as the area of the square is to the area of the circle.

Let Fig. 3 represent a square 1 sq.in. in area. If we draw a circle that will just fit inside the edges of this square, as in Fig. 4, the diameter will be 1 in.

We know the length of the line which bounds the square is 4 in., and, from what we have learned of 3.1416, or π, we know that the line which bounds the circle is 3.1416 in.

*Some one has taken the trouble to carry it out to 127 places: 3.14159265358979323846264338327950288419716939937510582097494592307816406286208998628034825342117067982148086513282306647093844 + In 1873, a Mr. Shanks carried it out to 707 places.

Now, expressing all this as a proportion we have

$$4 : 1 = 3.1416 : N$$

or the area of the circle.

Dividing the product of the means to find the other extreme we have

$$\frac{1 \times 3.1416}{4} = 0.7854 \ sq.in$$

We have now proved that the constant 0.7854 represents the area in square inches of a circle 1 in. in diameter. If the area of the circle is to be figured in square feet, square yards, square miles, etc., this constant is also used because the relative value remains the same no matter what unit of measure we may use.

FIG. 3

FIG. 4

RINGS

The ring, Fig. 5, is really a cylinder bent into a circular form, so the volume will be the same as that for a cylinder whose altitude is equal to the mean circumference or the length of the dotted line *A*. The mean circumference will be twice the distance *OA* multiplied by 3.1416 or π.

If the radius or distance $OA = R$, and the radius of the cross-section $BA = r$, the formula for the volume of the ring will be

$$V = \pi \ r^2 \times 2 \ \pi \ R$$

and for the area of the ring's surface

$$A = 2 \ \pi \ R \times 2 \ \pi \ r$$

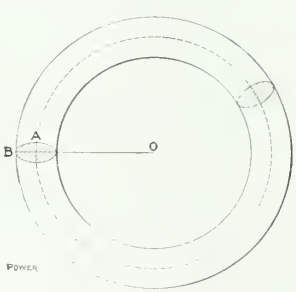


FIG. 5

Fig. 6 shows a flat, circular ring like a gasket.

It is easy to see that to find the area of one face we proceed as follows:

Rule: *From the area of the large circle subtract the area of the small circle.*

The area of the large circle will be

$$12^2 \times 0.7854 = 113.09 \ sq.in.$$

The area of the small circle will be

$$6^2 \times 0.7854 = 28.27 \ sq.in.$$

and the area of the flat ring will be

$$113.09 - 28.27 = 84.82 \ sq.in.$$

A ring of rectangular section is shown in Fig. 7. The volume of such a ring may be found similarly as for the circular ring, being equal to the volume of a prism whose altitude equals the mean circumference of the ring. This is so because this ring is really a prism bent into a circle.

If

R = Outer radius;
r = Inner radius;
T = Breadth of face;

we have the following formulas for:

$$Mean \ radius = \frac{R + r}{2}$$

$$Mean \ circumference = \pi \ (R + r)$$

$$Area \ of \ cross\text{-}section = (R - r) \ T$$

$$Volume = (R - r) \ T \ \pi \ (R + r)$$

Superficial area or area of all four sides =

$$\pi \ (R + r) \times 2 \ [(R - r) + T]$$

Another, and perhaps the commoner, method of finding the volume or area of a square ring, is to find the area of one face, as was done for the gasket or flat ring, and

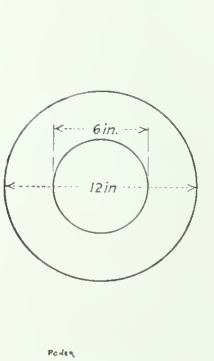


FIG. 6

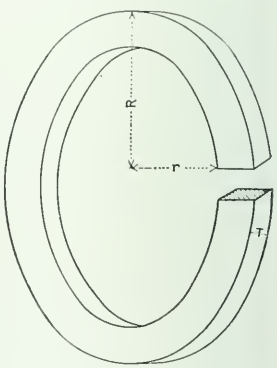


FIG. 7

multiply by the thickness. The volume would then be equal to

$$(\pi \ R^2 - \pi \ r^2) \ T$$

and the total or superficial area to

$$2 \ (\pi \ R^2 - \pi \ r^2) + T \ (2 \ \pi \ R) + T \ (2 \ \pi \ r)$$

Example: A flywheel rim has an outer radius of 144 in., an inner radius of 139 in., the breadth of the face is 20 in. What will the rim weigh, cast iron weighing 0.26 lb. per cu.in.?

We see that the formula for volume must be used.

$$Volume = (R - r) \ T \ \pi \ (R + r)$$

$R = 144$ in.;
$r = 139$ in.;
$T = 20$ in.;

substituting these values, we have

$$Volume = (144 - 139) \ 20 \times 3.1416 \times (144 + 139)$$
$$= 88,907.28 \ cu.in.$$

The weight will be

$88{,}907.28 \times 0.26 = 23{,}115.89$ *lb.* Ans.

Example: What will be the area of all four sides of this flywheel rim?

The formula is

$$Area\ \pi\ (R + r) \times 2\ [(R - r) + T]$$

substituting the known dimensions we have

$$Area = 3.1416\ (144 + 139) \times 2\ [(144 - 139) + 20]$$
$$= 44{,}453.5\ sq.in.$$

Check for correctness the formulas used in the last two examples, by working the same problems with the other formulas given.

Examples for Practice

(1) A winding engine has a drum 8 ft. in diameter. In what time will the engine haul a cage up a 482.6-ft. shaft if the drum makes 20 r.p.m.?

(2) How many square inches will there be in a gasket for the flanges of a 6-in. pipe, area occupied by the bolts to be deducted? (A flange for a 6-in. pipe is 11 in. diameter and has eight ⅞-in. bolt-holes.)

(3) What will be the weight of a cast-iron pipe 12 ft. long, 2 ft. in outer diameter and 1 in. thick; cast iron weighing 0.26 lb. per cu.in.?

Answers to Last Week's Problems

(1) (a) 237,945.6 gal.
(b) 1 hr. 9 min. 4 sec.

(2) 476,367 cu.in.
(a) 2062 gal.
(b) 17,176.5 lb.

Where the Sediment Forms

The sediment in a boiler will accumulate in the portion of the bottom near to the region of the bridge-wall in the furnace; and if you have no such thing as a bridge-wall it will accumulate where the fire is hottest. This is a result of heat movements that send the hot water upward from highly heated spots while the cooler water surrounding sweeps in below, carrying with it sediment that builds a little mound; this, of course, if there is some one spot that is materially hotter than the rest of the surface exposed to the fire.

We all know the result; that the sediment forming in a heap keeps the water from the iron at this very spot till the heat causes the iron to bulge down into what we call a bag; but there is a lesson as well as a result. In the first place, the fireman should strive to have his heat distributed as near equally over the bottom of the boiler as is possible. It is not practical to get it so, strictly speaking, but a careful man can so manage his furnace and fires that the heat will be so well distributed that there will not be much of this accumulating of sediment in one spot, and then he can keep his boilers a little cleaner; and that will help some, too.—*National Engineer.*

Safety suggestions from employees are invited by the safety committee of the Lehigh Valley Railroad. The employee who makes a suggestion, whether or not it is adopted, receives a report as to what was done about it, with the reasons therefor. On each division the man who makes the best suggestion in the year toward increased safety of operation is given an "honor button" and a month's vacation with pay. In addition annual passes will be granted men with clear safety records for a year.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

R. O. Richards charges us with "dangling." Then he dangles this dinged dangle before us:

"Editor of the jays (J. J. J. J.) column:

"In the Feb. 18 issue, I note that you dangle before the eyes of your readers two ways of making easy (?) money. I thank you. In return, let me tip you to a far easier way. Uncle Sam is about to issue a new five-cent piece. Collect 1913 nickels; they are worth $95.65.

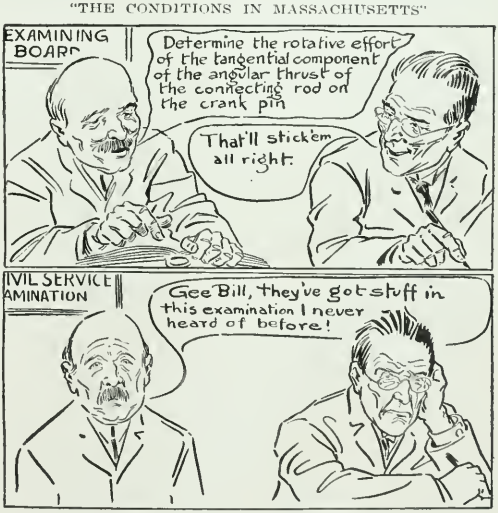
"Framingham, Mass. R. O. RICHARDS."

R. O., your initials stand for "Ring Off"! You've got the wrong number if you think we're not hep that

$1913 \times 0.05 = 95.65$ (perfectly good dollars).

It almost surpasses belief that a lumber-mill engineer should possess one million real green dollars, but that's what the papers say of James Bennett, of Marshfield, Ore. Of course, this sum does not represent his savings; it was willed to him. They also say, "James does not wish to leave his job." Stick, Jimmy, stick! Buy the sawmill and you will have something handy when you start cutting coupons.

"THE CONDITIONS IN MASSACHUSETTS"


EXAMINING BOARD
Determine the rotative effort of the tangential component of the angular thrust of the connecting rod on the crank pin
That'll stick'em all right
IVIL SERVICE AMINATION
Gee Bill, they've got stuff in this examination I never heard of before!

"THE EXAMINERS EXAMINED"

Once in a while, someone gets even with the dentist. A lady named Peck got a bushel of money ($384) in a suit (a "law" suit) from Dr. Stevens because he pulled the second upper left bicuspid when he should have pulled—some other. Steve Brodie took a chance and so did the other Steve, but there's more than one kind of bridge work and more than one kind of Steve gets gotten. Get it?

In this column, on Feb. 18, we asked our readers to "dig up a postcard and name offhand the names of ten men famous in the history of steam engineering. Prof. William Kent promptly responds with this list.

Savery—First practical pumping engine.
Newcomen—Cylinder and piston reciprocating engine.
Watt—Separate condenser, rotative engine, governor.
Oliver Evans—High-pressure, non-condensing engine.
Fulton—Application of Watt's engine to steamboat.
Stephenson—Improvements in locomotive.
Sickels—Drop cutoff.
Corliss—Attaching drop cutoff to governor.
Porter—High-speed engine.
De Laval—First commercial steam turbine.

Prof. Kent adds Parsons and Stumpf, for good measure.

Oil as a Fuel

By Reginald Trautschold

SYNOPSIS—Discussion of the use of oil as a fuel for generating steam. Emphasizes its advantages over coal in greater convenience and cleanliness and less labor of handling, and even claims equal or better economy in many sections not at present regarded as favorably located to burn oil.

About half a billion tons of coal is now mined in the United States per year, including bituminous and anthracite coals of all grades. Of this amount probably two-fifths is used to generate steam for use in stationary engines. At the same time, the yearly production of crude oil is close to three hundred million gallons, of which a considerable part is being used to develop power in three ways: By using the crude oil itself in internal-combustion engines of the Diesel type; through the explosive use of certain byproducts, as in gas and gasoline engines; and as fuel for generating steam for use in steam motors. The last of these three will be discussed in this article.

This use of oil as fuel does not appear to be as universal as it might be, probably due to lack of general knowledge of the efficiency that can be expected when such fuel is carefully and scientifically used and to the fact that fuel oil is not obtainable at a reasonable price at all times. The first of these drawbacks should be easily surmountable and it will be the object of this article to present some general information and facts pertaining to the question. The second drawback is more difficult to overcome but, as it can be controlled to a certain extent, should not bear sufficient weight to unreasonably retard the more extensive use of this exceedingly convenient and usually economical fuel.

Substituting fuel oil for coal in the production of steam, evades many of the drawbacks of adopting other means of generating power in the ordinary existing steam plant. No unheaval in the engine room, accompanying discard of valuable equipment, addition of new engines, etc., nor radical changes in the engine-room force and management are necessary. This does not mean that the field lost to the gas engine, where natural gas or gases from oil refineries are procurable, can be regained by using oil as a fuel, nor that the surprising economy of certain internal-combustion engines of the Diesel type can be equaled by any possible gain in economy in steam generation, due to using oil fuel. It does mean, however, that oil fuel must now be considered as a serious competitor of coal in many localities where the power plant depends for its operation upon steam.

Before considering the requirements for an economical oil-burning system it will be well to clearly understand

What Constitutes a Good Fuel Oil

or what its specifications should be. This will anticipate the common criticism that fuel oil is an unsafe fuel, subject to accidental ignition, etc. Fuel oil is frequently referred to as crude oil and possibly this is the reason for the erroneous idea of its danger, for crude oil is a fuel oil only when its flashing point is high and the oil comparatively free from gasoline and naphtha. Crude oil itself is a mixture of a number of hydrocarbons which may be separated through the agency of heat and in a crude oil with *low* flashing point the first distillate gases given off in refining are very explosive so that such an oil cannot be safely used as a fuel oil.

Gasoline is driven off at a temperature of from 140 to 160 deg. F., during the distillation of crude oil, and at a temperature of 200 deg. F. the lighter benzines or naphthas have been separated from the crude. The residue, should distillation be stopped at this point, would be an oil that could be handled as safely as coal, but the specifications for fuel oil generally call for a fire test of 250 to 300 deg. F., such oil contains little naphtha and cannot ignite accidentally if ordinary precautions are taken. A shovelful of red-hot ashes can be thrown into a tank of such fuel oil without danger, or a red-hot poker may be used to stir it without fear of an explosion or ignition.

Following in the order in which the various oils are distilled from crude comes kerosene, which constitutes about one-half the mixture. This is also a good oil for fuel but is naturally considerably more expensive than fuel oil and cannot be, therefore, considered as a practical substitute for coal for any but very small engines. The present discussion will be limited, therefore, to a brief description of the equipment and requirements for a fuel-oil system.

Equipment for Oil Burning

Between a steam plant operated on coal and one on oil fuel, the only difference lies in the boiler rooms: the engine rooms are identical. The alterations or additions in the boiler room are neither radical nor complicated so that a plant operating on coal can easily, quickly and inexpensively be converted into an oil-burning plant by adding a few comparatively simple mechanisms and equipment. All that is required is the installation of oil burners in the furnace doors; proper protection of the grates and all exposed metal parts of the firebox with firebrick; a reservoir or storage tank for confining the oil; apparatus for pumping the oil to the burners, with means of regulating the pressure at which the oil is delivered and facilities for preheating the oil before delivery; a steam connection between the boiler and oil burner for vaporizing the oil; and the piping that may be necessary for connecting up the system.

Without going into an extended analysis of the thermal value of fuel oil or of ways of firing such fuel, it may be stated that one gallon of good fuel oil per hour will furnish sufficient heat to develop from 2½ to 3 hp. Oil burners, proportioned to so regulate the consumption of oil, are procurable in a compact form with connections for the supply of oil under suitable pressure and for the supply of steam to vaporize the oil as delivered from the burner. Simple hand valves, forming part of the mechanism of the burners, regulate the supply of both steam and oil, the first of which should be delivered under constant pressure for hand regulation of the furnace and at variable pressure if mechanical regulation is used.

To facilitate atomizing the oil and to maintain the constancy of its supply under given pressure, it should

be preheated to reduce its viscosity and thus the pressure required to assure proper delivery. The steam required for vaporizing is obtained directly from the boiler, when in operation, and its pressure should be reduced to an equivalent of from 3½ to 4½ times that at which the oil is supplied to the burners. The apparatus for preheating the oil, subjecting it to pressure, etc., is usually in the form of one compact unit; has considerable capacity; is comparatively inexpensive and is all the mechanism that is required to complete the system. The oil-storage tank, preferably of a capacity sufficient to take care of the oil requirements for a considerable period, if the price of ful oil fluctuates to any considerable extent or if oil is not always readily obtainable in the locality of the power house, is also comparatively inexpensive and should be

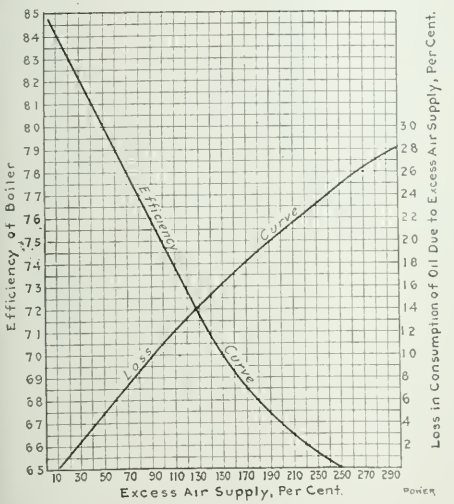

Efficiency of Boiler
Loss in Consumption of Oil Due to Excess Air Supply, Per Cent.
Efficiency Curve
Loss Curve
Excess Air Supply, Per Cent.
POWER

Chart I. Effect of Air Supply on Efficiency of Boiler and Consumption of Oil—Oil-fired Boilers

installed underground, with proper vents, etc., so as to minimize the insurance burden. The piping connecting up the various parts of the system should also be installed underground when possible and made as simple as the installation will allow.

The Efficiency of the System

depends, to a great extent, upon the supply of air for combustion. This is important no matter what kind of fuel is burned, but is especially so with oil fuel, as upon it largely depends the economic value of the installation. The boiler efficiency of the average plant burning coal is much more frequently around 40 or 50 per cent. than 60 or 70 per cent., and only the exceptionally efficient installation will show over 70 per cent. With oil, this boiler efficiency can be greatly increased, owing to the possibility of concentrating the heat and the decreased loss due to radiation. A boiler radiation loss of but 3 per cent. or better can be obtained, in an oil-fired boiler, by proper conservation of heat in the fire chamber by covering all metal parts, not in direct contact with the water, with good quality firebrick and controlling the supply of air in the combustion chamber.

A given supply of oil requires a specific volume of air for complete combustion (theoretical air supply) but practically the best efficiency is obtained with an excess air supply of about 10 per cent. With this excess a boiler efficiency of about 85 per cent. may be realized in an oil-fired boiler with properly proportioned firebox carefully protected with good quality of firebrick and the flame of the burner directed against a correctly located wall of firebrick and so as not to touch the metal of the boiler. An air supply of 10 per cent. over the theoretical requirement, however, is a relatively small volume and several fold this amount may easily be admitted unless the disadvantage is fully realized by the operator or furnace man, and constant care taken in regulation. An excess air supply of only 300 per cent. will reduce the boiler efficiency to under 65 per cent., or about that which would ordinarily be obtainable with coal as fuel, and would necessitate burning nearly 30 per cent. more oil to maintain the requisite boiler pressure—see Chart I. Here evidently lies the key to the economy of the oil-burning system, for one properly installed and operated will develop the same power from a boiler capacity of 60 to 80 per cent. of that required when burning coal.

Efficient Oil Burning

is indicated by the appearance of the combustion chamber and the condition of the exhaust passing to the smoke-

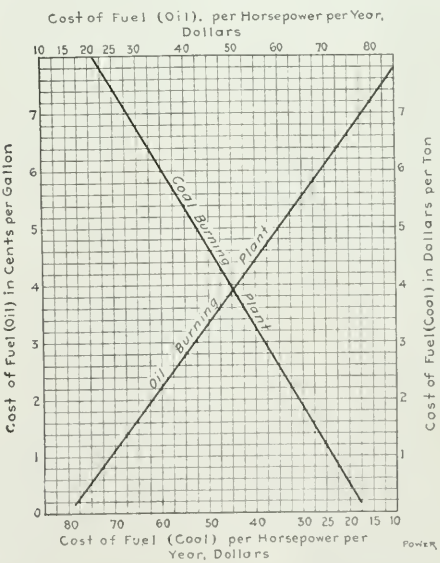

Cost of Fuel (Oil), per Horsepower per Year, Dollars
Cost of Fuel (Oil) in Cents per Gallon
Cost of Fuel (Coal) in Dollars per Ton
Coal Burning Plant
Oil Burning Plant
Cost of Fuel (Coal) per Horsepower per Year, Dollars
POWER

Chart II. Average Cost of Steam Power, Based on a Plant of 500 Hp.

stack. The combustion chamber should show a clear white incandescence, with only a slight apparent flame, and no smoke or unburned gases should pass to the smoke-stack. Such conditions can only be recognized through practice, but, when the correct appearance is known to the furnace man, they can be quite easily maintained.

The economy in oil consumption is then dependent upon the minimum supply of oil requisite to maintain the desired pressure on the boiler. This, in an installation where the load is fairly constant, can be controlled by

hand by an experienced man, and then the supply of oil is regulated under constant pressure and the air supply by hand-operated dampers. Where the load fluctuates considerably, hand regulation is difficult and mechanical control should be installed. In a mechanically controlled system the oil outlet in the burner is maintained constant and the supply of oil regulated by the delivery pressure. This variation in oil pressure, which is directly dependent upon the fluctuations in the load, is made use of to regulate the admission of air to the combustion chamber, an increase in load producing an increase in oil pressure and a corresponding enlargement of the air-admission passage and *vice versa*.

TABLE I. AVERAGE FIXED CHARGES OF THE POWER HOUSE

Based on Plant of 500 Hp.

Oil Burning Plant

Engine room:—			
Building, etc		$10	
Engines, accessories, piping, etc		30	
Foundations, installation, etc		5	
		$45 per horsepower	
Depreciation	.5% total cost		
Repairs	2%		
Interest	6%	Total, per horsepower per year.	
Insurance	1%		Item A—$7.20
Taxes	2% ¾ cost		
Boiler room:—			
Building foundations, etc		$4 50	
Chimneys, flues, etc		7 00	
Boilers, etc		7 50	
Oil burning systems (complete)		3 00	
		$22 per horsepower	
Depreciation	.5% total cost		
Repairs	2%		
Interest	6%	Total, per horsepower per year,	
Insurance	2%		Item B—3.63
Taxes	2% ¾ cost		
Cost of operation:—			
Engine room,			
Attendance		$1 80 per horsepower per year	
Supplies		0 80	
		2 60	Item C—2 60
Boiler room:			
Attendance		$1 10 per horsepower per year	
Supplies		0 47	
		$1 57	Item D—1.57
Total fixed charges, per horsepower per year			$15.00

Coal Burning Plant

Engine room:—			Item A—$7 20
Boiler room:—			
Building, foundations, etc		$5 00	
Chimneys, flues, etc		8 00	
Boilers, feed pumps, etc		12 00	
		$25 per horsepower	
Depreciation	.5% total cost		
Repairs	2%		
Interest	6%	Total, per horsepower per year,	
Insurance	1%		Item B—3.87
Taxes	2% ¾ cost		
Cost of operation:—			
Engine room:			Item C—2.60
Boiler room:			
Attendance		$1 90 per horsepower per year	
Supplies		0.90	
		$2 80	Item D—2 80
Total fixed charges, per horsepower per year			$16.47

An efficient oil-burning system for boilers compares favorably with the ordinary coal burning from an economic standpoint as is indicated in Chart II. This chart is plotted from Tables I, II and III, which were compiled from various data pertaining to steam plants of about 500-hp. capacity and are sufficiently accurate to permit a comprehensive comparison between plants of that size operating on oil and on coal.

Chart II also affords means for forming a conservative opinion as to the relative economies of any size plant operating on the two fuels with the respective fuels at various prices, for the relation existing between the cost of fuel and the average cost of power is practically constant in any ordinary size of power plant under efficient management, since in larger plants the fixed charge per unit of power is reduced and the consumption of steam is relatively less while in smaller plants the reverse is true.

TABLE II AVERAGE COST OF FUEL FOR THE POWER HOUSE

Based on Plant of 500 Hp.

Fuel Oil		Coal	
Per gal.	Per hp. per year	Per ton	Per hp. per year
$0 01	$9 00	$1 00	$7 20
0 015	13.50	1 50	10 80
0.02	18.00	2.00	14 40
0 025	22.50	2 50	18 00
0.03	27.00	3.00	21.60
0.035	31 50	3.50	25.20
0 04	36 00	4 00	28 80
0 045	40 50	4 50	32 40
0 05	45 00	5 00	36 00
0 055	49 50	5 50	39.60
0 06	54 00	6 00	43.20

TABLE III AVERAGE COST OF STEAM POWER

Based on Plant of 500 Hp.

Oil Burning Plant		Coal Burning Plant	
Cost of Oil per gal.	Steam Power per hp. per year	Cost of Coal per ton	Steam Power per hp. per year
$0 01	$24 00	$1 00	$23 67
0 015	28 50	1.50	27 27
0 02	33 00	2 00	30 87
0 025	37 50	2 50	34 47
0 03	42 00	3 00	38 07
0 035	46 50	3 50	41 67
0 04	51 00	4 00	45 27
0 045	55 50	4 50	48 87
0 05	60 00	5 00	52 47
0 055	64 50	5.50	56 07
0 06	69 00	6.00	59 67

Advantages of Oil Fuel over Coal

Oil is more easily and cheaply handled than coal, can be stored at less expense and when stored does not deteriorate, minimizes standby losses, and is more convenient and cleanly. Of even greater economic importance are decrease of loss of heat generated in the furnace, due to concentration and more even distribution of heat, and diminished radiation losses; the fact that the boiler and its tubes are kept free from nonconducting deposits, such as are precipitated from the gases in coal burning; the conservation of heat lost when burning coal because of the necessity of opening the furnace door to fire; the ease with which the intensity of the fire may be regulated; and the rapidity with which steam may be raised. Still other benefits are the saving in labor and the absence of expense entailed in handling and disposing of ashes. These advantages are represented in the increase of 20 to 40 per cent. in the steaming capacity of the boiler fired on oil, to which reference has already been made.

The possible economy in fuel consumption from the use of fuel oil and the numerous benefits accruing from its use would doubtless bring about its rapid introduction but for the

Unreliability of Supply at Constant Price

This condition does not exist in sections of the country near oil wells and there the use of oil has already become general. In many other parts of the country the average price of fuel oil compares favorably with that of coal, but the fluctuations in the price of oil are great. Even here a judicious purchase of oil when cheap and maintaining a comfortable reserve for use during periods of elevated

prices will enable relying on oil for fuel without paying an exhorbitant price for it, for at some time during each year oil is usually procurable at a favorable price for economic power development.

One influence at work tending toward a more uniform price for fuel oil is the steadily increasing demand for gasoline brought about by the automobile. An excellent fuel oil is left as a residue after distilling gasoline from crude oil and a constant demand at a uniform price for gasoline will mean a constant and low price for fuel oil unless the demand for other heavy byproducts of crude oil should unexpectedly increase.

Signification of Torque

By Franklin Van Winkle

SYNOPSIS—Terms expressive of rotary power may at first be misty to engineers whose experience has been confined to reciprocating engines. Ambiguity in use of the term torque has led most Continental authors to discard the word from their writings. The article describes the method of measuring the torque of a motor and defines the relation of torque to horsepower and kilowatt.

Many engineers upon first acquaintance with electrical machinery reserve their confidence in ordinary switchboard indicators as means for determining power output. It requires, however, only short practical experience in care of electrical generators and motors to convince the most skeptical that the voltmeter, ammeter and wattmeter are as faithful monitors of power product as the steam-engine indicator is of the performance of the reciprocating engine.

"Kilowatt" soon becomes as familiar an expression for amount of power as "horsepower." But after long practice in computing power developed by the piston of a reciprocating engine, one is apt to hold in mind, as a

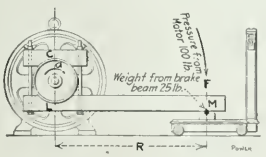


Fig. 1.

fundamental concept, that power consists of work performed in a straight line, and engineers who have been reared in the gospel of the old school of steam engineering are prone to consider that the electric-motor and steam-turbine practice have brought into the power field methods of computing power that are not entirely reconcilable with the older methods of computation. It is erroneous to assume, however, that the era of rotary motors has brought with it any actual innovations in dynamical computations, for it is rather from motives of greater convenience than novelty that the terms expressive of energy of rotary power are introduced. For most part they are only modifications of expressions which are quite as ancient to the mathematician and physicist as the time-honored P-L-A-N formula is to the steam engineer; anyone versed in the old power nomenclature who will give a little attention to the subject of motors, soon finds himself using terms and formulas for estimating rotary power with as much facility as he ever had employed data obtained with the steam-engine indicator.

Probably no term used in connection with generators and motors has given rise to more confusion in the minds of operating engineers than "torque," and this is probably because the word is used with two analogous though different meanings, viz., one signifying the mechanical rotary or turning force which acts on the armature of an electric generator or motor causing it to rotate, or in general, the forces employed in rotating the armature; and another which signifies the summation of the moments or leverages of the turning forces applied to an electric generator or other machine which turn it or cause its rotation.

The term torque is, therefore, used to stand for both (a) a mechanical "force" or "pull" at the periphery of the armature, such as is known in mechanics as "tangential effort"; and (b) the moment or leverage of the tangential effort, i.e., the tangential effort multiplied by its radius of action. This ambiguity has caused most Continental writers to discard the word "torque" altogether. But with us the word is so generally used in both senses that the American engineer must differentiate the significance of the term as he may chance to meet it.

In referring to details of construction of generators or motors, one may have occasion to use the word in its narrower sense of "tangential effort," but as a power-plant engineer he is concerned with the broader sense of the term, viz., as a moment of tangential effort. Employed in the latter sense, the torque of a generator or motor usually signifies equivalent pounds of pull at the end of a radius or arm 1 ft. long.

Most operating engineers know the meaning of brake power and if they will trace out the relations which these definitions bear to brake power, the term torque will be regarded as a novelty only in name.

Suppose, as indicated in Fig. 1, a motor has a driving pulley which rotates in the direction of the arrow *a*. A clamp brake *CLM*, suitable for resisting rotation of the

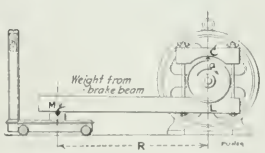


Fig. 2.

driving pulley, affords means for determining torque and for testing the power developed by the motor when it takes a given current, if account is taken of (1) the horizontal distance, *R* (as 1 ft.) from the center of the driving pulley to the point *M*, where the brake arm is supported on a platform scale, (2) the force *F* (as 100 lb. pressure) with

which the action of the motor presses the brake arm down on the scale, in addition to that weight of the brake beam which is supported on the scale, and (3) the number of revolutions N (as 500 per minute) made by the motor in a stated time.

If now the brake beam is reversed and when freely

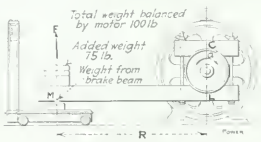


FIG. 3.

supported with the motor at rest as shown in Fig. 2 the pressure due to the brake beam alone is observed, and weights T are added to the arm, as shown, Fig. 3, so as to make the total weight the same as the downward pressure which was created on the scale in addition to the dead weight of the brake arm when the motor was driven as shown in Fig. 1, then the brake would be suitably loaded for creating the same resistance as the resistance overcome in Fig. 1. Then if the motor were supplied with the same current as before, the clamp of the brake could be tightened so as to just hold the brake arm poised as shown in Fig. 3.

In either case it is to be recognized that the torsional effort exerted by the motor would be precisely the same as though the motor pulley consisted of a drum, as shown in Fig. 4, having a radius R equal to the effective length R of brake arm as in Figs. 1, 2 and 3, and the effort would be the same as if the motor were actually employed in

FIG. 4.

raising a weight F of 100 lb. through a cord or cable suspended over the periphery of the drum.

If the distance R is 4 ft. then for each revolution of the drum the weight would be raised through a height equal to the circumference of the drum, i.e., the distance would be $2\pi \times R$ or

$$(2 \times 3.1416) \times 4\ ft. = 25.1328\ ft.$$

and if the weight amounted to 100 lb., then the motor would develop.

$$2\pi \times (R \times W) = 2 \times 3.1416 \times (4 \times 100) = 2513.28\ ft.\text{-}lb.$$

for one revolution.

The quantity $R \times F$ is called the moment of rotation and to raise the weight, as in Fig. 4, or overcome an equivalent brake resistance, as illustrated in Figs. 1 and 3, it is evident that an equal and opposite moment must be exerted tangentially by the motor in the direction of the arrow a, Figs. 1 and 3. The pull thus required will depend on its distance of action from the center of the motor shaft, for the tangential force multiplied by its distance would have to equal $R \times F$.

It is evident that in considering the power of a motor, the term torque should be used only as meaning the product of $R \times F$, as far as concerns exertion of turning effort, it is inexplicit to use the term to signify pull at the periphery of the armature unless the radius of the armature is distinctly understood.

In any case the same turning effort would require $R \times F$ to have the same value and to avoid ambiguity, torque should be restricted to mean *turning moment*.

If the armature has a radius of R ft. and a pull at the periphery of F pounds in any case

$$2\pi \times (R \times F);$$

then if we know the pull at the circumference of the armature and the radius of the armature the torque will be the product of these two factors.

In each of the cases illustrated by Figs. 1, 3 and 4 it is to be seen that the energy exerted per revolution was

$$2\pi\ (R \times F);$$

i.e., the number of foot-pounds exerted per revolution would be $2\pi \times$ the torque, and consequently $2\pi \times$ torque $\times$ r.p.m. = ft.-lb. per min.; or, taking the figures quoted, with 500 r.p.m. the number of foot-pounds developed per minute would be

$(2 \times 3.1416) \times (4 \times 100) \times 500 = 1,256,640\ ft.\text{-}lb.$

Dividing this amount by 33,000 we obtain 38.08 hp.; or dividing by 44.24 we obtain 28,405 watts, or 28.4 kw.

From the above it appears that when torque is regarded as the moment of rotation, then

$$\frac{2\pi \times torque \times r.p.m.}{33{,}000} = horsepower$$

and

$$\frac{2\pi \times torque \times r.p.m.}{44{,}240} = kilowatts$$

To Encourage Cleanliness in Plants

A good way, if not the best way, to encourage cleanliness of machines and of the factory in and about the machines, is to keep conveniently at hand the implements necessary to secure cleanliness—brooms, brushes, cotton waste, etc. In some plants the sweeping is given over to some one man on each floor, and where this is done it may not be advisable to provide a broom convenient to every machine man. But one thing that should always be handy and within reach is cotton waste, something to clean the oil and dirt off of parts of machinery. This should be kept where it is easily accessible.

It is better to have them destroy and waste a little of it unnecessarily than it is to be stingy with it and let the machines suffer for want of cleaning. Both waste and receptacle for the waste should be provided—that is, a box, or preferably a metal can, for holding the clean waste, and also a metal receptacle for the dirty waste. This oily waste is a dangerous thing to have thrown around carelessly in the corners, and should always be kept in a covered metal box or can of some kind to prevent danger from fire. It also contributes to neatness and orderliness.—*Wood-Worker.*

Accident to Twin Tandem Engine

A peculiar accident happened to a twin-tandem-compound Corliss condensing engine running at 78 r.p.m. and developing about 1800 hp., in the plant of the Berkshire Cotton Mfg. Co., Adams, Mass., on Feb. 11. According to our correspondent, one of the cross-head shoes came loose in some manner, broke in two pieces—one piece flying out through the engine-room door and the other barely missing the head of Howard Kaiser, assistant engineer. The mill was shut down a few hours while a new shoe was fitted.

⁂

Piston Explodes

Another instance of where "they did not know it was loaded" is related by a correspondent. In a machine shop at Hadley, Alaska, on Jan. 22, two men were heating a piston and piston rod in a forge, preparatory to straightening the rod, when the piston exploded. Fortunately, no one was injured and the damage done was slight. The explosion is said to have been due to the presence of water in the piston. On the application of heat, the pressure due to the formation of steam caused the explosion.

⁂

Blowoff Tank Explodes

A rather odd accident happened at the Colorado Springs high-school building, on Jan. 30. The heating plant has two 14-ft. by 60-in. boilers, operated at 60 lb. steam pressure so as to drive an engine and fan. The blowoffs from these boilers are connected to a small cast-iron reservoir 3 ft. in diameter and 3 ft. deep, which in turn is connected to the city sewer by means of a 4-in. siphon reduced to 2 in. just outside the reservoir. The 2-in. pipe has one elbow before it reaches a 4-in. sewer pipe 4 ft. away.

A week previous to the accident, the blowoff pipe on one of the boilers had become clogged between the boiler and reservoir. The engineer could not shut down and take out the pipe because of the very cold weather at that time, so he tried forcing it out by opening the blowoff under 60 lb. pressure. As usual, the space between the back of the boiler and the partition wall was narrow and the reservoir was situated just at the entrance of this narrow alley.

As the engineer opened the mud valve he heard the rush of water as the pipe cleared itself and he was just on the point of backing out and letting it blow for awhile when there was an explosion, filling the boiler room with hot water and steam, and before he could get the valve closed he was badly scalded.

The pipe from the reservoir to the sewer had become choked so that the pressure increased enough in the reservoir to rupture the ½-in. cast-iron cover. Two pieces hit the ceiling with force enough to go through, but were stopped by the floor above.

⁂

Our juvenile contemporary "Blow-Off" had an article recently on "Taking Care of Little Things" which at first sight we thought bore on the wage question, but it didn't. Little "Blow-Off" is hitting right from the shoulder on other matters. Bore in, neighbor, you've got lots of steam behind your punch.

NEW PUBLICATIONS

THE INDICATOR HANDBOOK. A practical manual for engineers by Chas. N. Pickworth, Whitworth scholar, editor of the "Mechanical Works," etc. Part II. The indicator diagram, its analysis and calculation. Pages, 139, 5x7, illustrated, cloth, price 3s. Emmott & Co., Ltd., Manchester, England. D. Van Nostrand Co., New York.

The Pickworth handbook appears to be the favorite English manual of the steam-engine indicator. The resetting for the fifth edition has furnished the author an opportunity to extend the work in several particulars, especially the chapter dealing with diagrams from gas and oil engines. He points out that in the first edition of his work a gas-engine diagram was reduced to logarithmic coördinates, and the value of n for the compression curve determined, as has just been done by Mr. Clayton.

MATERIALS AND CONSTRUCTION—A Texthook of Elementary Structural Design. By James A. Pratt. P. Blakiston's Son & Co., Philadelphia, Penn. Cloth; 196 pages, 5x7 in.; 85 illustrations; tables. Price, 90c.

The book gives an elementary treatment of materials and the laws of construction. It is intended for trade-school students so that no attempt has been made to cover any advanced engineering work. The following list of chapters will give some idea of the contents: Elementary Principles, Materials, Elementary Calculations and Properties, Beam Design, Columns, Torsion, Action of Elementary Forces and Their Consideration in Design, Proportions of Knees and Counters, Riveted Joints, Reinforced Concrete, Tables and Data. In correctness and simplicity of treatment the book fulfills its purpose, and should be of value to the student interested in mechanics.

SHOP MATHEMATICS—Part I: Shop Arithmetic Prepared in the Extension Division of the University of Wisconsin. By Earle B. Norris and Kenneth G. Smith. McGraw-Hill Book Co., New York City. Cloth; 187 pages, 6¼x9½ in.; 86 illustrations. Price, $1.50.

To teach the fundamental principles of mathematics to shopmen is the aim of the book. The first twelve chapters are devoted to simple arithmetic, such subjects as fractions, percentage, ratio and proportion, areas and volumes, square root, etc., being treated in very simple style, with plenty of examples to drill the reader in the work. The balance of the book contains chapters on levers, tackle blocks, inclined plane and screw, work, power and energy, horsepower of engines and belting, mechanics of fluids, heat and strength of materials. This part of the book is intended to develop an ability to use simple formulas and simultaneously impart a knowledge of the principles of machines. The problems and applications relate largely to the metal-working trades, but are of just as much interest and value to the engineer in the power plant. References to everyday applications of the subjects mentioned and illustrations of familiar machines and devices make it easy for the reader to grasp the points of a problem. Due to the simple and direct treatment the book should prove specially valuable in home study.

THE THEORY OF ENGINEERING DRAWING. By Alphonse A. Adler, B. S., M. E. D. Van Nostrand Co., New York. Cloth; 289 pages; illustrated; 6x9 in. Price $2.

As the author states in his preface, the subject matter of this book is, in large measure, the same as dealt with in treatises on descriptive geometry. The chief aim is to correct the weaknesses considered to exist in the manner of presenting the theory of descriptive geometry.

The title is very appropriate considering that descriptive geometry applies more to engineering than to any other field, and because the author treats of its relation to engineering. Contrary to the usual manner of working up the subject by starting in with definitions and considerations of the orthographic projections of a point and going thence into the theory of the projection of lines, surfaces and solids, the author reverses the process by first considering a concrete object and then working up to the theory. The purpose of this method of presentation is to make it easy to understand each successive step of the subject.

The book is divided into four parts Part I treating oblique projection and orthographic projection, which includes axonometric projection; Part 2, an interesting variety of problems relating to the line, the point and the plane; Part 3, problems in perspective, and Part 4, shading.

The book will be found very useful to those who have to do with or are interested in the theory and commercial application of drawing. The volume is well adapted to home study, as a number of questions are given after and relating to each chapter.

THE METRIC SYSTEM. By Henry G. Bayer. Ninety-four 4x6½-in. pages; 13 illustrations in the text; 26 tables of equivalents. Price, 35c. Henry G. Bayer, 232 Greenwich St., New York, N. Y.

This little book has been prepared to furnish in useful form to the student, engineer and manufacturer, needful data in regard to the metric system. The author is an enthusiastic advocate of the system, but this does not blind him to the strength of the arguments in opposition; in fact these major arguments are briefly and accurately stated in the opening paragraph on page 11.

The history of the system, its definitions, rules, etymology, 26 conversion tables and explanatory problems are given. The general heads are: Measures of Length, of Surface, of Volume, of Capacity, of Weight (mass), of Value; Miscellaneous Measures Used in Physics and Engineering, and Thermometers.

The tables, which are among the most important and perhaps the most useful features have been worked out with care and completeness. They alone are sufficient to recommend the book, for too often the engineer exasperatingly fails to find the particular equivalent of some compound English unit when he wishes to make a conversion to the metric system. The book will be found of value to anyone having occasion to use the metric system.

LEFAX. Loose leaf engineer's reference book founded by John Clinton Parker, published by the Standard Corporation, Pennsylvania Bldg., Philadelphia, Penn. A year's subscription, $1. Size of pages 3¾x6⅝-in. Loose leaf binder, leather covered, 90 cents.

With the evident idea of giving the engineer ultimately all the data which he needs to keep on hand, in the shape of loose-leaf sheets, so that he need carry for reference only such pages as are most important to him, J. C. Parker has hit upon the scheme which has now borne fruit in "Lefax," (Leaf-facts).

It takes care not only of the data sheets published by the Standard Corporation, but of the engineer's own notes, and of data published in periodicals, for such may be filed on blank sheets of the same standard size as the data sheets, and indexed among them. Clippings can be so pasted or a synopsis of the article written on the blank sheet. Subscribers are invited to suggest subjects for data sheets, and such as furnish data sheets which are accepted will be paid for them at the rate of $5 a sheet, provided such information is original.

On each sheet a filing index is printed, which can be modified at the individual user's pleasure.

In the sample sheets sent out are tables of logarithms, circumferences and areas of circles, the 1912 standard of flange fittings, actual evaporation per boiler horsepower and factors of evaporation for saturated steam, properties of saturated steam from the new Marks & Davis tables, actual evaporation per boiler horsepower and factors of evaporation of superheated steam, 100 deg. superheat, sheet metal and wire standard gages, and an example of the advertising sheets sold to manufacturers of equipment for presenting data of interest to engineers. The one given among the samples is from the Parker Boiler company, and describes the design of a Parker downflow boiler.

PRACTICAL MATHEMATICS, PARTS I, II AND III. Bound separately. By Claude Irwin Palmer. Published by the McGraw-Hill Book Co., New York City. 5x7 inches. Cloth. Price 75 cents per volume.

These three books are the first of a series of four volumes treating of mathematics. The series is the outgrowth of the course in mathematics given the evening classes of the Armour Institute of Technology. These little books are well adapted to the needs of practical men who must get a working knowledge of mathematics by home study.

Part I (138 pages) begins with a review of arithmetical terms and work which nearly every man has learned in the lower grades of the grammar school.

The following chapters take up common and decimal fractions, weights and measures, percentage, ratio, proportion, powers and roots. The exercises consist of working out problems that are met with in every day work in the shop, engine room, and in the building trades.

Part II (150 pages) treats solely of the essentials of geometry. Plenty of exercises are given so the student may get a good training in the working of problems relating to triangles, circles, prisms, cylinders, spheres, pyramids, cones, frustrums, etc.

Some examples in geometry relating to the work of the carpenter, machinist, mason or engineer, are fully explained and worked out. This book concludes with a list of 61 geometrical formulas and five tables.

Part III (176 pages) takes up algebra. The author treats the subject so feared by most practical men in a manner which is necessarily lengthy on account of the simplicity with which the matter must be presented.

At the end of each lesson a number of examples are given with their answers so that the student may know whether or not he has worked his problems correctly by reference to these answers.

Engineers will find Chapter 15 of this volume to be of a special interest to them in that it takes up the essentials for plotting graphics.

THE ELEMENTS OF HEATING AND VENTILATION. By Arthur M. Greene, Jr. John Wiley & Sons, New York, 1913. Cloth; 324 pages, 6x9¼ in.; 223 illustrations, tables. Price $2.50.

The book is a general treatment of heating and ventilating systems, covering hot-air, hot-water and direct and indirect steam heating systems, particular attention being given to residence heating. Formulas for the amount of air required for ventilation are deduced and supplemented by tables from various authorities. This data is naturally followed by a description of humidifiers and washers for cleaning the air. The subject of heat losses from rooms is given considerable space. The various common forms of building construction are illustrated with data and formulas for calculating the heat loss and the heat required for ventilation. Radiators and valves of various types are illustrated and the subject of heat transmission through radiators is taken up at length. In direct steam heating, the single-pipe, double-pipe and over-head systems are compared and in the chapter following, gravity hot-water systems are given attention.

Indirect heating is limited to 65 pages. To illustrate the natural-draft system, the size of the flues and ducts and the amount of the heating surface is calculated for a two-story house. The plenum or forced-draft system is applied to a school house. The flow of air is taken up and formulas for the drop of pressure in pipes and bends are given. Methods for measuring the quantity of air by pitot tubes, standard orifices, anemometers, venturi meters and electric meters are explained and tables are given of pressures and the velocities of air and the diameters of pipes required for various capacities. Several forms of fans and housings are illustrated with problems showing the method to be pursued in determining the size of a fan for a given case.

In the section devoted to hot-air heating, a system is laid out and all calculations made for a two-story house. The details of furnaces and boilers and the points governing their selection are taken up and following is a description of the relative merits of steam, hot-water and hot-air systems.

District heating with steam and hot water is compared and the concluding chapter is devoted to thermostatic temperature control and the use of air for drying.

Due to the number of subjects discussed, the treatment is necessarily brief and, as the book deals mostly with house heating and ventilation, its value as a general reference book is limited in the same proportion to this particular branch of the art.

Proposed Maine License Law

In the Maine Legislature an act to provide for licensing engineers of stationary engines has recently been proposed by Mr. Harman, of Stonington. The bill contains 10 sections.

Section 2 declares that whosoever desires to act as engineer of a stationary engine shall apply for a license therefor to the secretary of state. The application must show the applicant's total experience and be accompanied by the fee of $2.

The bill will allow an owner or user to operate a steam boiler for one week without a license. If the secretary of state decides that the applicant has properly answered all the questions in the application, and "the applicant has had the required two years' experience as a fireman," a license will be granted to operate a stationary engine in any part of the state of Maine for a period of two years unless revoked for incompetency or negligence. He must be "a citizen or naturalized citizen of the United States," of good moral character and of sober habits.

It is also proposed that a license may be renewed at the end of the two years without the $2 fee for renewal if the application is made within six months from the date of expiration of the license.

A violation of these rules subjects the engineer to a fine of not less than $100 or more than $500, imprisonment for not less than 30 days or more than three months, or both. The trial justice, the municipal and the police courts will have jurisdiction of offenses under the act.

Employees Share in Profits

Profit-sharing by employers with their employees received a practical endorsement at a banquet held in the Hotel Walton, Philadelphia, Monday evening, Feb. 17, at which were gathered the thirty-two associates and employees of the New York and Philadelphia offices of the architectural and engineering firm of Ballinger & Perrot.

Walter F. Ballinger presided, and gave a brief address explaining the profit-sharing plan which had been decided upon. This division will be upon a two-fold basis; the first, the division of a certain sum set aside from the profits in which all the employees will share equally, irrespective of their salaries. Second, there will be a division of an additional amount based upon the proportion which each employee's salary bears to the total amount of salaries paid.

Mr. Ballinger announced that the past year had been the most successful the firm had ever handled, and it was due, in a great measure, to the efficiency and coöperation of the employees. Emile G. Perrot then distributed checks to the employees, representing their proportion of the profits of the past year on the basis outlined.

Profit-sharing has proved so satisfactory that the firm has decided to extend the plan to all of its employees, from the highest to the lowest, believing thereby to obtain an increased coöperation and efficiency throughout their entire force. No pretense is made that the plan is a species of philanthropy, it being their firm belief that fair treatment of the employees is of mutual benefit to employer and employee.

Members of American Institute of Steam Boiler Inspectors Dine

The annual dinner of the New York section of the American Institute of Steam Boiler Inspectors was held at the Oak Hotel on Friday evening, Feb. 21, to commemorate the second anniversary of the founding of the society. About sixty members and guests were present and although not a large assemblage, they made up for lack of numbers in the enthusiasm shown.

As a mark of appreciation, the society presented its retiring president, J. W. Winter, with a handsome gold watch, T. T. Parker making the presentation.

Among the speakers were several representatives from other cities. These included Mr. King and Mr. Malloy, of Boston. The latter told of the Boston section of the American Institute of Steam Boiler Inspectors, its organization, educational program and policy.

Philadelphia was represented by Mr. Lukens, chief inspector of boilers for that city. He made a plea for uniform boiler laws and incidentally mentioned that since the Philadelphia laws had been in force there had not been a boiler explosion in that city.

The government service was represented by Mr. Arklebaum, who made a few remarks.

Mr. Fogarty, of Brooklyn, spoke from the viewpoint of the boiler manufacturer. He told how difficult it was to build a high-grade boiler to compete with an inferior one under existing conditions, and also threw some light on the present city inspection of steam boilers by the police department. He strongly advocated the adoption of state boiler rules for New York similar to those now in force in Massachusetts and also advocated giving insurance inspectors the power to shut down a boiler which they did not believe safe.

F. G. Shaw, the newly elected president, then spoke of the aims of the society and heartily endorsed what the other speakers had said regarding uniform boiler laws. Upon the motion of T. T. Parker, the society adopted a resolution providing for the presentation of a bill to the present legislature, for boiler laws based on the Massachusetts rules.

Thomas Wilmott, a member of the Assembly from Brooklyn, pledged his support of such a bill when drawn up.

Brief speeches were also made by a number of other members and guests and R. A. Thompson was re-elected secretary for the ensuing year. A splendid musical program added to the attractions of the evening.

Members and Guests at Dinner of American Institute of Steam Boiler Inspectors

SOCIETY NOTES

A meeting of the American Institute of Consulting Engineers to further discuss "Professional Relations" will be held at the Engineers' Club, 32 West Fortieth St., New York City, Tuesday evening, Mar. 11, at 8 p.m. The discussions of L. B. Stillwell and S. Whinery at the last meeting were printed in "Engineering News" of Jan. 23, page 155, and it is hoped that the members will read these articles and come prepared to speak. There will be an informal dinner at 6:30 at the same place just before the meeting.

In a paper read by K. Cox on "Internal Combustion Engines" recently, before the Yorkshire section of the Institution of Electrical Engineers, the author established comparisons between three different classes of plant as follows: In regard to capital cost, that of a 650-kw. turbine generating plant amounting to £8850, as against £960 for a gas engine installation and £11,080 for a Diesel engine installation of similar power. The running costs for the three plants under equal conditions were as follows: Steam plant, 0.232d. per brake hp.-hr., and 0.348d. per kw.-hr.; gas engine plant, 0.195d. and 0.292d. respectively, and Diesel engine plant, 0.268d. and 0.047d. respectively.

OBITUARY

PATRICK W. CANTWELL

Patrick W. Cantwell, a boiler maker, for many years in the department of water supply at the Ridgewood pumping station, Brooklyn, N. Y., and long the president of the Boiler Makers and Iron Ship Builders Association of America, died.

Feb. 7, at his home in Greenpoint. He was born in the Eastern District 54 years ago and lived in Greenpoint 30 years. He is survived by his widow and three daughters.

CARL GUSTAF PATRIK de LAVAL

Carl Gustaf Patrik de Laval, of Stockholm, Sweden, died recently in the sixty-seventh year. He was born at Blåsenborg, County of Orsa, Province of Dalarne, Sweden, May 9, 1845. His father was Capt. Jacob de Laval, of the Swedish Army; his mother's maiden name was Johanna Martin. A mechanical taste became evident in his childhood, for he loved to take apart and put together pieces of mechanism, such as watches and gun locks. His parents were wise enough to let his inclination develop. Having continued his home instruction until the age of 12, they sent him to school in Salun, Sweden, and at 18 he was a student in the University of Upsala, Sweden. It is said also that he was enrolled in the University of Stockholm. At all events, he reached his college graduation with high honor in 1866. De Laval's first employment was with the "Stora Kopparberg," a mining concern, where he found that he needed a better scientific education and thereupon returned to Upsala, taking up postgraduate study in chemistry, physics, mathematics, etc. In 1872, having attained the doctorate of philosophy, he reentered the service of the "Stora" company. About this time he journeyed to the Harz Mountains, in Germany, to study the manufacture of sulphur or sulphuric acid, a plant for the production of which was projected at Salun.

Going to Germany in 1875, he became mechanical engineer for the Kloster Iron Works, where he invented a sort of sieve for improving the distribution of air in bessemer converters. He also invented a new apparatus for galvanizing purposes. More significant were his experiments with the centrifugal cream separator, which perhaps has made his name even more widely known than did his steam turbine later.

Prof. Lefeldt, it is fair to mention, was working with the separator idea at about the same time as de Laval. The latter, seeing its possibly enormous utility, and having failed to persuade the Kloster concern to take up its manufacture, surrendered his employment with them, in 1877, and went to Stockholm to exploit the invention himself. Since that time, the sales of his cream separator have amounted probably to a million machines. The mechanism has undergone important improvements over the original pattern, among them being a continuous delivery of cream and skimmed milk from their respective outlets. De Laval made other inventions in the dairy business, including the "Lactotrite," "Emulser," and "Continuous Churn." The "Lactotrite"—which we understand to be the same as the "Lactometer"—is an instrument for automatically analyzing milk to show its quality. Previously it had been customary to determine the proportion of cream, but de Laval's instrument accurately indicates its richness in butter fat.

Following the establishment of his cream-separator industry, Dr. de Laval founded at Olofström, Sweden, a factory for stamping out steel utensils, which has grown into a very important national industry. At heavy cost, he experimented with a steamboat to develop high speed on a new principle, but was not very successful, and, although confident that he had the right idea, he decided to drop it and put his time and money into the steam turbine.

As long ago as 1870, he had experimented with a nozzle for a steam sand blast to be used for making mine borings, the edges of which nozzle were so inclined as to cause rotation. This, though of little account in itself, turned his mind in a fruitful direction. About 1882, he constructed his first steam reaction turbine. It was a simple one, on the principle of Hero's engine, the rotor being essentially an S-shaped outward-flow pipe. It was geared with friction bevel wheels whose pressure was produced by the axial thrust of the turbine wheel. This turbine did not expand the steam enough to run at very high speed.

In one or more of these early experimental turbines he used water (condensed steam) for bearing and stuffing-box lubrication. The shaft rested on a stephearing inclosed in a vessel filled with water under high pressure, which kept the shaft up to a certain level. If it rose higher, the water escaped, relieved the pressure and allowed the shaft to drop back. By this construction a considerable power was developed, but the bad lubrication caused heating at the higher speeds, and it seemed impossible to make a tight packing between the steam inlet and the fast rotating wheel.

To introduce the steam without impeding the rotation of the wheel, de Laval tried the plan of initially converting a part of the energy into kinetic form. This gave it the velocity required when it reached the rotor and the consequent lowering of pressure allowed a play of one-half to one millimeter without leaking.

Doctor de Laval's first commercially practical turbine was built in 1883, and was used to drive a cream separator, directly connected. Its efficiency was low, due to the slow peripheral speed and imperfect steam expansion.

It was not until 1888 that he arrived at the system of completely expanding the steam and employing it in an axial turbine. For this purpose, he used a multiplicity of nozzles in which the steam expanded to atmospheric pressure and produced a corresponding velocity. The wheel was designed for this velocity and the turbine was an axial impulse one which ran at a high number of revolutions per minute. At the close of 1888, de Laval invented the flexible shaft that allowed the wheel to revolve at a speed limited only by the strength of the material, thus perfecting the principle of his turbine. Tremendous were the practical difficulties that he surmounted in designing turbine wheels so constructed and balanced as to revolve around their centers of gravity at 16,000 to 30,000 r.p.m. without destructive side pressure on the bearings and to produce horsepower ranging up into the hundreds. In experiments he obtained even greater speeds.

De Laval formed his turbine business into a large incorporated company at Stockholm, Sweden, which had affiliated concerns in many countries, including France, Germany, England, Netherlands, Austria-Hungary, Russia and the United States. The number of his turbines that have been manufactured runs high into the thousands. They are employed for direct connection to dynamos, centrifugal pumps, blowers and other machines. Something like one in seven has been built for use on shipboard.

DOCTOR DE LAVAL

The demand by the turbine for high pressures of steam led de Laval to experiment with boiler designs, in which he applied new principles and aimed at absolute freedom from explosions. His boldness and unconventionality as an inventor may be judged from the fact that he worked with steam pressures of several thousand pounds per square inch.

He was an engineer of great versatility. One of his more recent inventions was a method for making iron pipe. He busied himself also with metallurgy, among his later patents being those on electric furnaces for direct production of metals from the ores, a method especially valuable in a country like Sweden, which is rich in water powers. A zinc-smelting plant on the de Laval principle was established at the Trollhätte waterfall, and still later he patented a furnace for smelting iron from a pulverized charge.

De Laval's personality was one which drew to him the respect and love both of his social peers and of his employees, and his valuable citizenship was recognized by the bestowal of national offices. He was elected a deputy to the Swedish Parliament, 1888-90, and later became a member of the Senate. De Laval's honors and decorations were many, he having received the Cross of Commander of Wasa, and the insignia of Knight of the First Class of the North Star. He was a member of the Swedish Royal Academy of Science, which presented him with a gold medal in 1892, and an honorary member of the Royal Academy of Agriculture. In 1904, the Association of German Engineers awarded him the Groshof medal for his pioneer work on the steam turbine.

POWER

Vol. 37 NEW YORK, MARCH 11, 1913 No. 10

THE NEED OF LEGISLATION

(Suggested by George B. Longstreet, Somerville, Mass.)

New Sharp Mill Spray Cooling Pond

By Warren O. Rogers

SYNOPSIS—Owing to the distance and elevation from and above the harbor, a cooling pond with 120 spray nozzles has been constructed. The nozzles are set at such an angle that opposite jets impinge against each other, which further assists in breaking up the water.

Much interest has been manifested by the mill men of New Bedford, Mass., in the successful operation of the spray pond of the Sharp Manufacturing Co., of that city. It is only the second of its kind in that section; hence the interest shown.

Most of the cotton mills of New Bedford are located close to the water front and can easily obtain an abundance of condensing water, with short intakes leading to the suction pipes of the circulating pumps. The Sharp mill, however, has not this advantage, as it is about one-fourth mile from the nearest source of condensing water supply and is at an elevation of 35 ft. above the mean water level at low tide.

Fig. 1. Spray Nozzles and Cooling Pond

With the building of the mill came the problem of obtaining a sufficient supply of condensing water. The cost of laying a line of large water pipe from the harbor to the mill, added to that of constructing an intake and pumping outfit, together with the cost of operation, made such a proposition prohibitive. Then, after due investigation, it was decided to build a spray cooling pond using fresh instead of salt water in the condenser. Naturally there is some loss by evaporation and by mist being blown away by the wind, which loss is made up from the city water main. A view of the spray nozzles and cooling pond is shown in Fig. 1.

In the engine room, which is shown at the left of Fig. 1, is a 30 and 68 by 60-in. cross-compound Corliss engine, Fig. 2, which runs at 80 r.p.m. The English system of rope drive is used, and four sets of line shafting are driven from the grooved flywheel. There is also a 14x32-in. simple, four-valve engine directly connected to an alternating-current, three-phase, 60-cycle 600-volt generator, running at 164 r.p.m. The generator carries a motor and lighting load, a part of the factory machinery being motor-driven.

Condenser Outfit

Both engines are connected to a counterflow barometric condenser installed in the engine room, a general view of which is shown in Fig. 3. Circulating water is supplied by a 12-in. impeller pump directly connected to an 8x12-in. four-valve engine running at 150 r.p.m. The 10 and 27 by 24-in. dry-air pump runs at 50 r.p.m.

The condenser outfit produces a vacuum of 28 in. in regular daily service as indicated by the mercury column attached to the exhaust-steam leg. At the time of the writer's visit the overflow registered a temperature of 100 deg. F., with a 28-in. vacuum. The hotwell temperature is maintained within 4 or 5 deg. of the temperature of the exhaust steam. The counter-current feature of the condenser and automatic vacuum breaker enables the operator to run the condenser without danger of losing the vacuum should the temperature of the hotwell be the same as the exhaust steam.

Boiler Room

The boiler plant contains nine vertical boilers, each of 225 hp. capacity. The flue gases go to a 175-ft. brick chimney which is built on the outside of the boiler room. Boiler-feed water is handled by two 12 and 7½ by 12-in. outside-packed duplex pumps after passing through a multi-tube, exhaust-steam heater, which raises the temperature to about 200 deg. F.

In winter the mill is heated by hot air by a 11x20-ft. fan driven by a 16x24-in. slide-valve engine, at 70 r.p.m. In summer the air is cooled and washed by passing through sprays of water, which also produces the proper amount of humidity, necessary in textile manufacturing. Air is carried to the various rooms through metal conduits entering near the ceiling. The air-washing water is supplied by a turbine-driven centrifugal pump at 1700 r.p.m. and is forced through 2000 small spray nozzles. The supply of air is regulated by automatic dampers which permit the proper amount to pass through the washing water.

All engines are lubricated by a gravity oiling system the storage tank of which holds 500 gal. There are two 250-gal. oil filters.

A 4½x4½-in., triple-cylinder, motor-driven air compressor in the basement supplies air for controlling the humidifying system and blowing out the generator and motors.

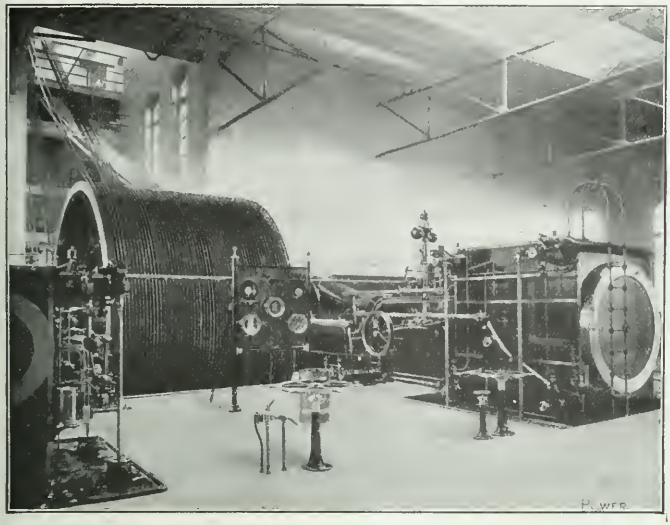


FIG. 2. CROSS-COMPOUND CORLISS ENGINE AND ROPE DRIVE

FIG. 3. GENERAL VIEW OF THE ENGINE ROOM

SPRAY POND

Circulating water is taken from the hotwell by a 12-in. centrifugal pump, directly coupled to a 30-hp. induction motor running at 1140 r.p.m., and forced through 120 two-inch spray nozzles. The pump house is at one corner of the cooling pond; the motor is controlled from the engine room.

The pond is designed to cool the water for a total of 3000 hp. of engines with a vacuum of 28 in. at the condenser. It is 4 ft. deep, 95 ft. wide and 140 ft. long and contains on the average, 400,000 gal. of cooling water. The condenser is supplied with water from a suction well at the end of the pond nearest the power house. A suction pipe from this well runs also to the fire pump, so that the contents of the cooling pond can be used for fire protection.

Three main spray lines branch out from a 14-in. header at the end of the pond nearest the power house. They are placed 25 ft. apart and extend lengthwise of the pond. At 12-ft. intervals the center spray heads are placed on the branch pipes, there being 24. Each head carries five 2-in. spray arms, each fitted with a 2-in. bronze spray nozzle, with a $\frac{3}{4}$-in. orifice. A gate valve is placed at the head of each branch pipe, and any branch of nozzles can be operated independently of the others.

A pressure of 5 lb. is maintained at the nozzles, which forces the water from the orifices in a fine spray. Each group of nozzles is set at an angle inclining toward the center nozzle, which is set vertical, so that the spray from one nozzle impinges

APPARATUS OF THE SHARP MANUFACTURING CO.'S POWER PLANT

No.	Equipment	Make	Purpose	Volts	Phase	Cycles	R.p.m.	Size	Pres. Lb.	Hp.	Manufacturers
1	Engine.	Corliss	Main units				80	30x68x60"			C. & G. Cooper Co.
1	Engine.	Rice & Sargent	Main units				164	14x32			Providence Engineering Co
1	Engine.	Porter-Allen	Circ pump				150	8x12			Southwark Foundry & Machine Co.
1	Engine	Ridgway	Fan				70	16x24			Ridgway Dynamo & Engine Co.
1	Turbine	Steam	Air water pump				1700			25	Kerr Turbine Co.
1	Generator	A.C.	Main unit	600	3	60	164				General Electric Co.
1	Motor	Induction	Compressor		3	60				10	General Electric Co.
1	Motor	Induction	Pond pump	600	3	60	1140			30	Crocker-Wheeler Co.
1	Compressor	Dayton	Air					$4\frac{1}{2}$x$4\frac{1}{2}$			Platt Iron Works Co.
1	Pump..	Centrifugal	Circ water				150	12"			Southwark Foundry & Machine Co.
1	Pump..	Porter-Allen	Dry air				50	10x27x24			Southwark Foundry & Machine Co.
1	Pump.	Centrifugal	Air washing water				1700				Buffalo Forge Co.
2	Pumps	Warren	Feed water					12x7$\frac{1}{2}$x12"			Warren Steam Pump Co
1	Pump..	Centrifugal	Spray nozzles				1140	12"			Morris Machine Works
1	Fan....	Buffalo	Heating				70	11x20'			Buffalo Forge Co.
9	Boilers	Manning	Steam gen.						150	225	Dillon Steam Boiler Works, D.M.
1	Chimney	Custodis	Smoke					175'			Alphonse Custodis Chimney Construction Co.
1	Condenser	Barometric	Main units								Southwark Foundry & Machine Co.
1	Gage	Mercury	Vacuum								Holman and Maurer
1	Heater	Reilly	Feed water								Griscom-Spencer Co.
1	Humidifier system	Automatic	Air washing								Carrier Air Condition Co
1	Oiling system	Fleur de Lis	Engines								Boston Steam Specialty Co.
1	Pond	Spray	Cooling water					95x140x4'			Spray Nozzle Co.
20	Nozzles	Spray	Cooling water					2"			Spray Nozzle Co.
9	Regulators	Williams	Feed water								Williams Gauge Co.

against that from the opposite nozzle, which assists in breaking up the water into still finer particles.

A feature worthy of note is the manner in which the spray-nozzle pump is piped, for water can be taken both from the condenser hotwell and also from the pond. This permits of spraying more water into the pond than is used by the condenser. This is desirable during the hot summer months, when the circulating water can be cooled to a lower temperature by pumping it through the nozzles more than once.

The water is taken from the hotwell at a temperature of 100 deg. F., and returned from the circulating pump at an average of 82 deg. F. in summer. The temperature of the pond water in winter is about 20 deg. F. above that of the atmosphere. In the fall and spring months the temperature of the air and water about balance.

The writer is indebted to Thomas R. Almy, master mechanic, under whose personal direction the plant was installed, for data pertaining to the various equipment.

Horizontal Baffles in Water Tube Boilers

By Albert A. Cary

SYNOPSIS—Discussion of different ways of baffling water-tube boilers, the objections to each and the author's conclusions from his own experiments as to how and where baffles can best be used.

In the Sept. 3 issue of Power, attention was called to the more or less troublesome horizontal baffles, commonly used in water-tube boilers. Mention was made of the bad effect on economy (and capacity might also be added) when holes occur through these baffles, due to their being either displaced or broken. The falling off in boiler performance, if they are removed, was also pointed out, and thus they remain, one of the necessary evils of the water-

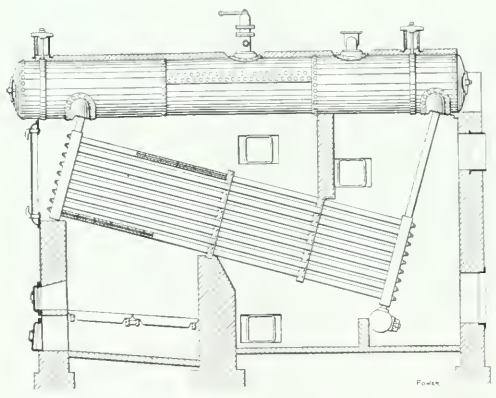


Fig. 1. Arrangement of Horizontal Baffles in Water-tube Boiler

tube boiler. How and where baffles can be used to the best advantage in this type of boiler has been made a serious study by the writer.

When a solid baffle closes the openings between the tubes, the hot gases from the fire are deflected or else are caused to flow along beneath them. If solid baffles are arranged as in Fig. 1, these gases run toward the rear of the boiler, under the lower row of tubes (and baffles) until they reach the opening near the vertical flame plate. They then flow upward through the bank of tubes, taking the shortest path, and escape through the opening at the top of the first pass between the end of the upper baffling (placed upon the top row of tubes) and the front header. By taking this direct path of least resistance, these hot moving gases have no chance to flow over those parts of the tubes immediately above the lower baffle and below the upper baffle and thus two stagnant pools of gas having little or no motion are found in these troublesome corners. As there are no fresh, active streams of hot furnace gases flowing through these pockets, the gas found there has very little additional supply of heat to replace the heat which has been abstracted by the tubes it bathes and consequently its temperature drops, thus making this part of the heating surface correspondingly less effective.

In three tests made by the writer to determine the temperatures existing throughout boilers of this type, which were equipped with but fairly tight horizontal baffles placed similar to the arrangement shown in Fig. 1, he found the following results:

	Degrees Fahrenheit		
	No. 1	No. 2	No. 3
Temperature of gases entering end of lower baffle	2640	2580	2020
Temperature above lower baffle	980	960	745
Temperature of flowing gases leaving top of tubes	680	660	605
Temperature beneath top baffle	510	490	430

In testing a water-tube boiler with horizontal baffling placed along the lower row of tubes and carrying the gases to the rear end of the boiler, he found

Temperature of gases entering the openings between the lower row of tubes	2010 deg.
Temperature above front end of baffle	420 deg.

The loss in heat transmitted is, unfortunately, not limited by the loss in temperature found in these dead spaces. A vessel containing water can have the temperature of its contents raised to the boiling point very much quicker when it is heated by the rushing flame from a blast lamp than when it has a quiet flame of equal temperature applied to its bottom. The rapidly moving gas flame passing over the heating surface with considerable velocity tends to decrease the film resistance which opposes the rapid transmission of heat. Thus a more rapid transmission of heat can be expected where the hot furnaces gases are constantly moving over the heating surfaces than when they are surrounded with an almost motionless envelope of gas.

The draft area, between the tubes in the type of water-tube boiler, shown in Fig. 1, is disproportionately large, especially for a fuel containing volatile matter. Usually this free draftway is almost 43 per cent. of the grate area. By comparing this draft area with that ordinarily found in horizontal tubular boilers (through the tubes) the difference is quite striking.

When the volatile gases are distilled from a fresh charge of bituminous coal, with the grate under the first

pass of a water-tube boiler not equipped with baffles, these gases, finding such a free path of escape among the tubes, rush upward, out of the hot furnace, and are in the center of the bank of tubes above before they have time to complete their combustion. As the temperature of these tubes is seldom above 365 deg. F. and as combustion ceases when these gases are chilled below 1400 deg. F., much of their available heat is lost, due to suppressed combustion, and smoky chimneys are likely under these conditions.

Partly closing the openings between the tubes, so as to decrease the draft area, opposes greater resistance to

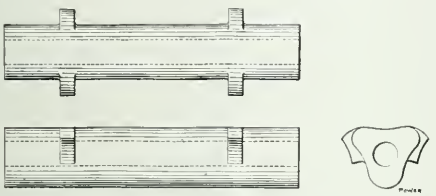


Fig. 2. Author's Special Form of Baffle Brick

the free escape of the unburned gases generated in the furnace and better results may be looked for.

Theoretically, all the furnaces gases should be completely consumed in the furnace and its combustion chamber before they enter the boiler where the surrounding chilly surfaces will lower their temperature below their critical temperature of combustion. Thus the need of some form of baffle to secure conditions which approach this theoretical requirement, becomes apparent.

Evidently, then, horizontal baffling in the passageways of the furnace gases in water-tube boilers has two purposes: to guide a constantly flowing stream of hot gases over the greatest possible area of the boiler's heating surface, and to promote the best conditions in the furnace, so as to secure the most complete combustion of the gases before they enter the chilling, heat-absorbing surfaces of the boiler.

The writer has experimented with various arrangements and forms of horizontal bafflings in water-tube boilers, using both the pyrometer and gas analysis to determine the results obtained and found the problem more complicated than he originally anticipated.

One of the first ways, and apparently the simplest, to overcome the objections cited above, was to place the solid baffles on the tubes so that a space would be left between their ends, which allowed the furnace gases to pass between them. This, at the start, showed a small improvement over the old, solid (end-to-end) arrangement and tests were made with even spacing between the baffles and also another arrangement was tried in which different distances between the various rows of baffles (running from side to side of the boiler) was tried. This latter arrangement proved the most satisfactory, but in continuous use the smaller openings soon became clogged with dirt. Further, these baffles became displaced from using the steam-cleaning pipe and due to other causes, so that many of the slit-like openings were closed, leaving undesirably large openings between the ends of other adjoining baffles. When the fire was forced, the burning gases rushed through these slits, like the flame of a blow pipe and impinged at separated spots upon the tube immediately above and, further, the ends of some of these baffles on the lower row showed evidences of fusing.

Another form of baffles used had vertical holes cast through their center, which were located over the space between the tubes. With this form of baffle, the blowpipe action, described above, when the fire was forced, was even more apparent. Some of the holes became clogged with dirt and breakage through the holes occurred.

Failing to find any other form of baffle to overcome these troubles, the writer invented a modified form of baffle to overcome the objections he had found, and has been allowed a United States patent for it. As it becomes interesting in the discussion of this subject, he offers the following description:

As the solid form of baffle proved so undesirable this principle of complete closure of the openings was discarded, and a throttling medium was chosen instead, which had the form of a specially shaped refractory brick, shown in Fig. 2.

At *A*, Fig. 3, it will be seen that this brick is easily introduced into the bank of tubes, by passing it between any two adjacent tubes. It can then be turned, as at *B*, and finally dropped into its normal position, as shown at *C*.

Owing to the tendency of this lower row of tubes to bend and sag it is generally desirable to insert such a form of baffle in the spaces of a row of tubes above. This is easy when using a stick or pole having a pin projecting

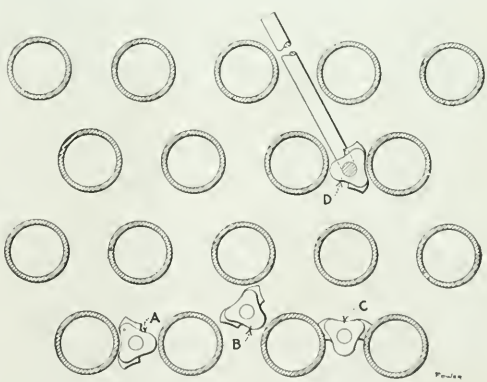


Fig. 3. How the Baffles Are Put in Place

at right angles to its axis and fastened to its outer end (the opposite end of the pole being held in the hand). With this projecting pin placed in the central hole (which runs lengthwise through the brick) the brick is passed downward (or upward) through the nest of tubes until the required position is reached, when the brick is turned and dropped between the tubes where required. This is illustrated at *D*, Fig. 3.

The brick is held in position between the tubes by four projecting lugs, which hold the body of the brick (in some cases ½ in.) away from the tube. Thus, in certain cases, instead of finding a 3-in. wide opening between the unbaffled tubes, with these throttling bricks in place, there will be an opening of only ½ in. on each side of the brick.

With the free draftway between the tubes thus throttled, enough hot furnace gases are passed along under the

lower row of tubes to completely bathe the rear end of the tubes in the first pass, while, at the same time, sufficient gas will pass through these throttled spaces, between the tube and the brick, to keep a mass of gas flowing constantly over the tubes above the throttled area.

A similar effect is produced under the top row of baffles (as shown in Fig. 1) where the dimmished openings will allow a flow of hot gases between the sides of these bricks and the tubes sufficient to break up the pocket of stagnant, motionless gas. At the same time, these upper throttling bricks drive enough of the gases forward to the front end of these tubes to surround them with an active flowing stream.

The top row of baffling brick can sometimes be placed to better advantage on the second row of tubes from the top, so that during the time of cleaning, men can walk over the top tubes without danger of displacing the bricks below their feet.

The passing of hot burning gases through the diminished opening cannot cause a blow-pipe effect upon the tubes above, when the furnace is forced, and as this thin stream of gas has water on one side to rapidly absorb its heat, the effect upon the solid side of the adjoining brick surface is not destructive.

The hole running lengthwise through the brick has another object. When a solid brick is quickly heated, its exterior is soon raised to a high temperature, while time is required for the heat to penetrate to the center and the reverse is true in sudden cooling (as when a furnace door is opened). This causes unequal expansion and contraction throughout the mass and solid baffle bricks are frequently broken, due to this cause. The hole through the center of this throttling brick reduces this trouble.

Expansion and contraction of the tubes themselves as well as their spreading or drawing together are cared for by the brick's form and location. The side lugs rest upon the upper part of the circumference of the tubes so that any diminishing of the distance between the centers of these tubes causes the whole brick to rise, thus avoiding a crushing effect.

A straight-edge laid across the top of the tubes will show that the whole body of the brick is below this level, and thus the steam-jet pipe can be used for blowing off the accumulated dust without interfering with the bricks.

The furnace element of this problem is also met with this throttling brick, as most of the gas distilled from the fuel is throttled back in the hot furnace, beneath the baffles and to secure the same effect as is obtained by solid baffling, a longer line of these throttling bricks must be used, due to the designed seepage which takes place along their entire length. Thus, the effect of a fire arch over the grates is more nearly approached, which becomes of greater value as the combustible volatile matter in the fuel increases.

These throttling bricks properly distributed in the last pass of the boiler (as in Fig. 1) will cut down the draft area there, causing a better distribution of the hot gases over the entire heating surface, followed by the lowering of the temperature of the escaping gases, thereby promoting economy.

The rational baffling of the hot gases passing through water-tube boilers, unfortunately, has received too little careful study. Consequently, many of the baffles used are designed with little other thought than providing some means for obstructing the flow of these gases, and the consequences following their misuse are seldom considered with a view of their effect upon the efficiency and capacity of both the boiler and furnace.

Deductions from Tests on Pipe Fittings

SYNOPSIS—A 4-in. swivel joint on a steam pipeline was tested as originally designed and as reconstructed with heavier flanges and more bolts to meet the requirements of the insurance inspectors. The latter arrangement, however, proved only 68 per cent. as strong as the former, due largely to the increased diameter of the bolt circle and the consequent greater leverage.

Interesting results have come to light in connection with some tests of pipe fittings, which were conducted by a corporation on fittings made in its own foundry for its own use. The tests were made under hydraulic pressure.

The principal test was that of a 4-in. swivel joint used on the vertical leg of a steam pipe from a boiler, to allow the easy movement of the main steam pipe under its natural contraction and expansion. Fig. 1 shows this joint in elevation and section as arranged for testing. It is now giving satisfactory service under a working pressure of 150 to 160 lb. This joint, as built to meet the demands of the insurance inspectors, for service at the same pressure is shown in Fig. 2. The flanges are 1¼ in. instead of ¾ in.; the base is 1 in. instead of ⅝ in. and the gland with its ring has eight bolts in place of four.

Several interesting features developed during the tests of these two joints. At 700 to 800 lb. pressure, all flat packing blew out and ⅞-in. packing, set in grooves as shown, became necessary. At 1100 lb., the flange on the brass sleeve began to dish (as shown dotted, Fig. 1). Ring *B* remedied this trouble. The 1⅛-in. heads also gave way at this pressure, and 2-in. heads were supplied. At 1500 lb., the new and supposedly stronger joint gave way, cracking the cast-iron ring directly over the split in the gland, as shown in Fig. 3. The bolts adjacent to the split were overstressed and lengthened while the other four bolts were entirely loose. The older form gave way at 2200 lb., when the base cracked, as is shown for two tests in Fig. 4.

This, apparently, does not admit of exact calculation. It may not be amiss, however, to inquire somewhat into the failure, and draw some conclusions therefrom.

In the first place, let it be noted that both the base and gland bolts were smaller than constitute standard practice for this working pressure. The stress in bolts of these sizes (⅝ in. and ¹¹⁄₁₆ in.), caused by the force necessary to make the joint tight, reduces the factor of safety very materially; in fact, experiments along this line lead to the belief that it is considerably below two, the additional stress resulting from the pressure not being considered at all.

Figs. 3 and 5 show in plan the split gland and bolts of both the old and the rebuilt joints. The pressure on the

shaded areas, in each case, is supported by the two bolts adjacent to the split. In the rebuilt joint, each of these bolts is assumed to carry one-sixth the total pressure load, the break showing that these bolts were stressed beyond the others. The line *AB* represents, in each case, the center line of the pressure and *CD* the center line of the

These tests and the results therefrom merit consideration from several points of view. In the first place, under 150 to 160 lb. working pressure, the system has a factor of safety of 5. It is no stronger than its weakest part, the packing, which could not be made to withstand over 700 to 800 lb. Manufacturers of fittings recognize

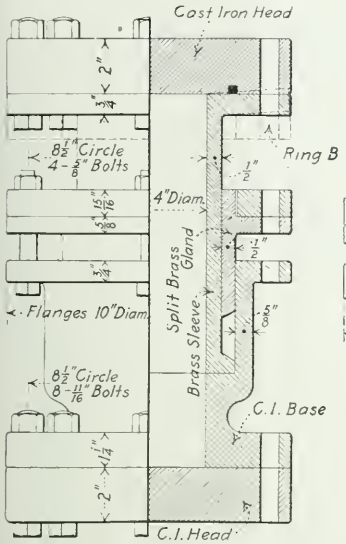


Fig. 1. Original 4-in. Swivel Joint

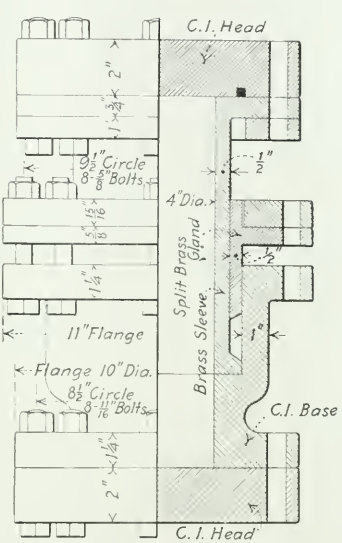


Fig. 2. Joint as Rebuilt

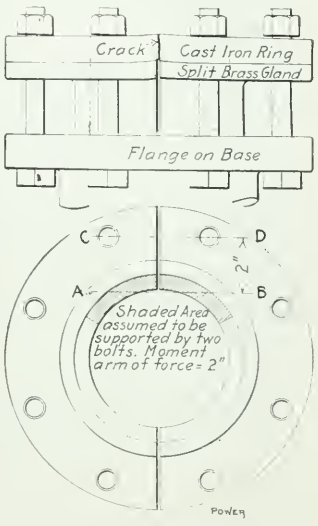

Crack
Cast Iron Ring
Split Brass Gland
Flange on Base
Shaded Area assumed to be supported by two bolts. Moment arm of force = 2"
POWER

Fig. 3. Gland Bolts on Rebuilt Joint, and Failure Indicated

resisting bolt pull. The eccentricity of the load, nearly double in the rebuilt joint, would seem to account for the failure, the bolts nearest the split lengthening and allowing the ring to give way.

Other tests by the same corporation, on its own high-

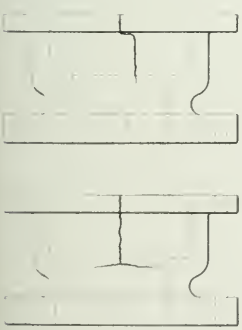


Fig. 4. Bases of Old Joint Showing Failure

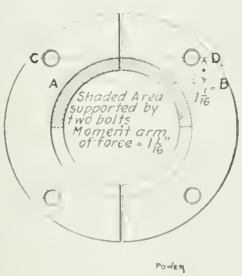


Fig. 5. Gland Bolts on Original Joint

pressure fittings, gave the following results: A cast-iron flanged tee gave way at 1800 lb., and a flanged elbow at 2300 lb., the failure in both cases being due to the flanges. Four-inch standard weight wrought-iron pipe gave way at 1600 lb. A threaded brass elbow began to leak at 2200 lb., and at 3300 lb. became so badly distorted that the pressure could not be held.

this in specifying grooved and lipped flanges on all extra-heavy work. The next weakest parts, the flanges on the sleeves and heads, have the very reasonable factor of safety of 7.

Moreover, the joint was rebuilt upon the refusal of the insurance companies to accept the risk as installed and, in the new form, met all their requirements. Yet, upon test, it developed only 68 per cent. of the strength of the original joint.

The most careful study is necessary to predict the behavior of a new design. In this case, notwithstanding the fact that the base and its top-flange were thickened, and the number of gland bolts doubled, this added strength was lost in the increase of the bolt circle.

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What is said to be the largest cable in the world was tested recently in the 800,000-lb. testing machine of the Fritz Engineering Laboratory, Lehigh University, South Bethlehem, Penn., when it withstood a pull of 364 tons before breaking. The cable consists of six strands, each of 19 wires, twisted around an independent wire-rope center, this center having six strands of 19 wires each, twisted around a hemp core. The finished cable was 7810 ft. long and weighed 125,360 lb. It is used by the Spanish-American Iron Co. in Cuba to lower wagons with a capacity of 100,000 lb. of ore down an inclined plane 5800 ft. long. "Mechanical World."

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The complexity of business done by the great German electrical manufacturing concern, the Allgemeine Elektricitäts Gesellschaft, is shown in a summary of the annual report printed in the "A. E. G. Journal" for December, 1912. Out of the business profits, a dividend of 14 per cent. will be distributed after setting aside 3,000,000 marks as a contribution to the reserve fund which now is increased to half the amount of the share capital.

Development in Marine Condensers

SYNOPSIS—Mr. Weir replies to Mr. Morison's criticism of his paper and depreciates his theory concerning films of air forming around the tubes. He is a firm believer in air pumps and thinks that an excessive vacuum for a marine turbine costs more than the gain.

In POWER of Jan. 21, an article on the above subject by William Weir before the Institution of Engineers and Shipbuilders in Scotland, was published, and following was a discussion of the paper by D. B. Morison, in which he presented a new theory of condensation. Mr. Weir's reply to this discussion may be of general interest.

In the first place, Mr. Weir objects to the importance and value placed on Prof. Weighton's paper of 1906. The paper in question dealt with the comparative performances of two condensers, one an old-fashoned rectangular condenser of small size, unrepresentative of practice at that date, and the second a condenser with certain special features of design. The trials show that the new condenser gave a better performance than the old one. Professor Weighton and Mr. Morison attributed the improvements to compartmental drainage of the feed water, so that the surfaces in the lower compartments are not impeded in their condensing action, abolition of the steam space and the substitution of a passage of such shape and section as to secure the distribution of the steam over the whole length of the tubes, and tubeless passages connecting the compartments.

The correct value of Professor Weighton's paper can be measured by the extent to which the alleged improvements have been embodied in modern designs. In the last four years Mr. Weir has personally been associated with the design of condensers for about nine million horsepower, embracing the most important examples in marine practice, and in not a single case are the condensers divided into compartments, nor are they sectionally drained; they have all more or less a steam space, and none of them have tubeless passages. Even in his own recent practice, Mr. Morison does not appear to embody these particular features to any extent. In the 1906 design of the Contraflo condenser, section drainage was provided for, but in succeeding designs this features has been gradually eliminated. The factor which was really responsible for the better performance of the 1906 condenser was undoubtedly the increase in velocity of flow of the circulating water through the tubes.

With reference to Mr. Morison's remarks regarding the provisions for dealing with large quantities of air leakage, resulting from accidental leakage into the system, Mr. Weir had had no experience of accidental leakage which a normal air pump could not handle satisfactorily until the accident had been repaired, and in his opinion there is no need of providing air pumps to maintain the highest degree of vacuum under other accidental conditions.

In the attainment of high vacua, Mr. Morison gave considerable space on how to best treat the small quantity of air which normally enters the condenser with the steam, and incidentally cited some experiments carried out by J. A. Smith to determine the effect of air on the heat transmission through a condenser tube. It was Mr. Weir's opinion that any theory or practice based on these experiments would be absolutely valueless, as the results could have no bearing whatever on surface condenser design or practice. Mr. Morison confirms the unfortunate effect of these results when he states that a film of air of minute thickness has a degrading effect on the heat transmission of a condenser tube. In the first place, there are no films of air, nor are there any films of steam in a condenser. There is a mixture of air and steam or air and aqueous vapor, each occupying the whole space. One of Mr. Weir's essentials of design is that the steam path must be such as to maintain a velocity of steam flow, and this is a most important factor. The relative weights of steam and air play no appreciable part in these condenser phenomena. In Mr. Smith's experiments the steam conditions were practically static, and the flaw in Mr. Morison's theory and conclusion is that he always considers a condenser in a static condition rather than in a working condition. The effect of air in a working surface condenser, is not in any way due to a resistance imposed on heat transmission by its presence and through being a poor heat conductor, but solely and simply to the physical conditions of temperature and pressure caused by its admixture with aqueous vapor.

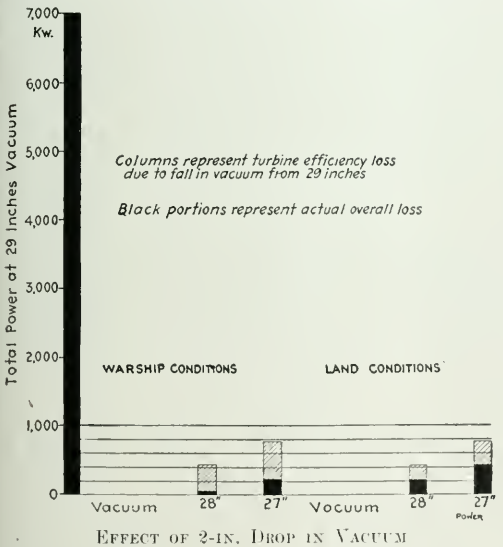
In a working condenser, the phenomenon consists of a mass of cooling surface working at high transmission rates with a more or less clearly defined air zone wherein the total transmission per square foot (not per degree difference per square foot) is impaired, due to the physical conditions of temperature and pressure. Accordingly, if the essential condition of uniform steam flow be maintained in a condenser design, the contour of the condenser becomes a wedge, and having obtained that, all else is dependent on the air pump, assuming fixed circulating-water conditions. The function of the air pump is to reduce the air-zone level, and to allow the working part of the condenser to extend itself, and only the air pump can perform this function.

Mr. Morison's remarks regarding eddies and means of preventing air particles making multiple appearances in any one plane can hardly be accepted as serious when the actual velocities are remembered. The idea of an air particle "lingering" in a modern condenser with uniform steam flow requires a great effort of imagination. The worst eddies in a condenser are those caused by the tubes. Any other eddy troubles are caused by the presence of baffle-plates or deflectors, such as were advocated by Mr. Morison.

In reply to the criticism of Mr. Morison concerning his statement that in reciprocating marine installations the highest attainable vacuum is not synonymous with overall economy, Mr. Weir refers to the diagram published by Sir Charles Parsons in the early days of the turbine, showing the effect of vacua on the steam consumption. This diagram was practically reproduced by Mr. Morison, and is probably literally correct, but is used and applied, and inferences drawn from it, in a dangerous and misleading manner. The diagram shows the effect of a drop of 2 in. in vacuum from 29 in. on the steam consumption of the main turbine. Mr. Morison applies this commercially, but take a power

station for example; money is not expended on the direct purchase of steam; it is coal which is purchased. The diagram does not show the effect of the vacuum drop on the only item which matters—the coal. The correction for the higher hotwell temperature and the reduced cost for circulating water for the 2 in. in question is a very important matter, but is completely ignored by Mr. Morison. As the effect of these factors varies according to the type of installation a diagram has been prepared and presented herewith, showing the necessary corrections for two conditions, the first being a power-station condition with 55 deg. inlet water and electrically driven circulating pumps; the second condition being a British warship with steam-driven circulating pumps, wherein the exhaust is led to the low-pressure turbine, and not to the feed water. As may be inferred from this diagram, Mr. Morison's figures, in the sense in which he asks them to be applied, are wrong to the extent of 35 per cent. in one case and 65 per cent. in the other.

Mr. Weir stated that his firm had recently supplied designs for a condensing plant to a foreign navy for a



Effect of 2-in. Drop in Vacuum

very high-speed cruiser, wherein the vacuum at full power is 27¼ in., and he is prepared to demonstrate that this will be the best vacuum for that ship at full power. In his opinion the value of a vacuum over 28½ in. for marine turbines is open to question. Almost everything in engineering is a compromise, and while on the one hand a fair percentage of improvement in the steam consumption might be obtained, on the other hand, the increased circulating-pump consumption, the increased weight and space for air and circulating pumps, the increased weight and space of the main condensers, the effect of reduced hotwell temperature, the increased weight and space of the low-pressure turbine to satisfactorily utilize the high vacuum must be considered, and, in the end, we may come, perhaps, to regard even for turbines a practical limit in the reduction of back pressure as desirable.

New Refractory Cement

The H. W. Johns-Manville Co., New York City, has recently put on the market the "J.-M High Temperature Cement No. 31" which, it is said, can be used wherever temperatures range between 1500 deg. and 3100 deg. F.

This material is a dry powder mixture composed of asbestos and other materials. It is mixed with water to the proper consistency by adding 18 to 20 lb. of water to 100 lb. of powder.

When used for setting firebrick for boilers and furnaces, lining and roofing furnaces of various kinds, lining fire-doors, repairing side walls of furnaces, making stay-nut caps, etc., it is said to have considerable mechanical strength, and that, when air dried, it will withstand a crushing strain of 883.5 lb. per sq.in. It vitrifies at the comparatively low temperature of 1418 deg. F. and has a high melting point, 3182 deg. F.

Being semi-acid in character, it can be used with chrome bricks, silica bricks or fireclay bricks. It is claimed that experiments with this cement show that it can be successfully used in building doors of angle-iron framework without backing, or for making one-piece linings for gas- or oil-burning crucible furnaces.

Connellsville Electrical Plant

The Western Maryland Railway Co. has been making a thorough study of the Western Penn Traction & Water Power Co.'s plant at Connellsville, Penn., and the proposed hydro-electric operations, having in view the possible use of power from this plant in connection with the proposed industries at Connellsville and other points.

Of the company's development operations, Austin Gallagher, its industrial commissioner, says: "This company has at the present time a steam plant at Connellsville with 52,000 hp. capacity, running on coal costing about a dollar a ton, which it is expected will favorably compare with almost any hydro-electric plant. In addition to the power now possessed, the West Penn Co. is preparing to put in three dams on the Cheat River, Va., which will produce 50,000 hp. each—the first to be in operation Jan. 1, 1914—and dams will be built on Sandy Creek, in West Virginia, providing more power.

"The company also controls the falls at Ohiopyle, Penn., where there is a drop of 110 ft. in a very short distance, together with the reservoir rights on the Youghiogheny River, so that ultimately there will be an electric power equal to 250,000 or 300,000 hp. that can be used for commercial purposes. The existing power is being carried 120 miles to Butler, Penn., under a voltage of 22,000; 3000 hp. is being conducted 28 miles to a large coal-mining company. At the present time, 110 coal mines, consuming 200 to 5000 hp. each, are being supplied from this plant. Municipal water-works also are being operated quite freely by electricity produced by this company. With the establishment of the hydro-electric plants, a voltage of 110,000 will be adopted for long distance."

The West Penn Co. claims to be selling power as low as any other plant east of the Mississippi and north of the Mason and Dixon line, and this development must of necessity become the center of a wonderful industrial growth, as these plants are located in the midst of millions of tons of coal that can be cheaply mined.

Factor of Evaporation

By A. A. Potter

SYNOPSIS—The tentative report of the subcommittee of the Committee on Tests of the American Society of Mechanical Engineers recommends the calculation of the factor of evaporation as for dry-saturated steam, and the use of a correction factor for departures from this quality.

The author considers it more simple and logical to compute the heat contents, whatever the quality, before dividing by 970.4 and shows simply how this is to be done for moist or superheated steam.

The factor of evaporation is that number by which the water evaporated in a boiler must be multiplied in order to obtain the equivalent evaporation from and at 212 deg. Thus it is the ratio of the "heat contents" of one pound of steam at a given pressure, reckoned from the feed-water temperature, to the latent heat of evaporation of steam at 212 deg.

The "heat contents" of one pound of steam at a given pressure is equal to the heat of the liquid (the h of the steam tables) plus the latent heat of evaporation at that pressure (the L of the steam tables) if the steam is dry. If the steam is wet, the latent heat of evaporation must be multiplied by the quality of the steam and this product added to the heat of the liquid in order to obtain the heat contents. When the steam is superheated, the product of specific heat of superheated steam by the number of degrees of superheat is added to the heat contents of dry steam at the given pressure. The total heat contents of a pound of superheated steam may be found in some of the steam tables for different pressures and degrees of superheat.

In the boiler code of 1912 submitted in the preliminary report of the power-test committee of the American Society of Mechanical Engineers and published in the November issue of the society's *Journal*, the method for calculating equivalent evaporation is given as follows:

"The equivalent evaporation from and at 212 deg. F. is obtained by multiplying the weight of water evaporated, corrected for the moisture in the steam, by the factor of evaporation. The latter equals

$$\frac{H - h}{970.4}$$

in which H and h are respectively the total heat of saturated steam and of feed water entering the boiler."

The method for correcting for moisture in the steam is given as follows:

"When the percentage is less than 2 per cent., it is sufficient merely to deduct the percentage from the weight of the water fed. If the percentage is greater than 2 per cent. or if extreme accuracy is required the factor of correction equals

$$Q + P\frac{(T - h)}{(H - h)}$$

in which Q is the quality of steam (one minus the decimal representing the percentage of moisture), P the proportion of moisture, T the total heat of the water at the temperature of the steam, h the total heat of the feed water, and H the total heat of saturated steam of the given temperature."

To calculate the equivalent evaporation by deducting the percentage of moisture from the feed water and multiplying the remainder by the factor of evaporation for dry steam is inaccurate and should be used only in approximate calculations.

In the process of steam generation, heat must be added to the feed water to bring its temperature up to the vaporization temperature at a given pressure, and when this temperature is reached the additional heat required for the vaporization process, or the latent heat of evaporation, depends on the final quality of the steam. Thus if the steam is 3 per cent. wet, the heat required to vaporize one pound of water at a pressure of 150 lb. abs. is 0.97 times 863.2, or 837.1.

In the above computation 0.97 represents the quality of the steam, or one minus the decimal representing the percentage of moisture; 863.2 is the latent heat of evaporation into dry steam at 150 lb. abs., or the heat required to vaporize completely one pound of water into steam at the given pressure. The value used here is that given in the Marks and Davis steam tables.

To obtain the heat contents of one pound of steam at 150 lb. abs. and quality 0.97 dry, the heat of the liquid, or the heat required to bring up one pound of water from 32 deg. to the vaporization temperature at 150 lb. abs., must be added to 837.1. This makes the heat contents:

$$837.1 + 330.2 = 1167.3 \ B.t.u.$$

In order to apply this to the calculation of the factor of evaporation, the feed-water temperature must also be known. If this temperature is taken as 130 deg., the heat of the liquid corresponding to this temperature, reckoned from 32 deg., is 97.89. Since the heat of evaporation at 212 deg. is 970.4, the factor of evaporation is:

$$\frac{1167.3 - 97.89}{970.4} = 1.11$$

For a boiler showing an evaporation of 5000 lb. of water per hour, the equivalent evaporation from and at 212 becomes:

$$1.11 \times 5000 = 5550 \ lb.$$

With dry steam, and other conditions the same as given in the above example, the factor of evaporation is:

$$\frac{863.2 + 330.2 - 97.89}{970.4} = 1.13$$

The equivalent evaporation from and at 212 deg. would be:

$$1.13 \times 5000 = 5650 \ lb.$$

If the temperature of the steam in the above example was 450 deg., or superheated:

$$450 - 358.5 = 91.5 \ deg.$$

the factor of evaporation becomes in this case:

$$\frac{863.2 + 330.2 + 0.57 \times 91.5 - 97.89}{970.4} = 1.18$$

in which 0.57 represents the specific heat of superheated steam or the heat in British thermal units required to superheat the steam one degree at the given pressure and temperature.

The equivalent evaporation in this case is:

$$1.18 \times 5000 = 5900 \ lb.$$

ELECTRICAL DEPARTMENT

Motors and Motor Applications—III

By A. B. Morrison, Jr.

Direct-current Motors

The construction of direct-current motors is so well understood that a description is unnecessary; consequently, only their operating characteristics will be considered. Direct-current constant-speed motors are of the shunt- or compound-wound type. For most installations, where the voltage is approximately constant, the shunt-wound motor gives more nearly constant speed. On circuits with widely varying voltage, the compound-wound motor gives better speed regulation than the shunt wound, and more satisfactory operation.

The ordinary commercial shunt motor will develop approximately 225 per cent. of full load torque with from 185 to 200 per cent. of full load current. Where the starting duty is heavy a compound winding is used by which the starting torque can be increased to 250 per cent. or more, depending on the amount of compounding with a starting current of 200 per cent. of full load current or above. Where constant speed is desirable under a varying load the compound winding can be cut out after the motor is up to speed.

There is one peculiarity of a shunt-wound motor as commonly used which is not always recognized. When the motor is operating "cold" (before the load has been on long enough for the motor to warm up) the speed is from 4 to 5 per cent. lower than after the motor is warm. This is due to the lower resistance of the fields when cold. In the case of centrifugal pumps particularly, where a given constant speed may be essential, the failure of the motor to run at rated speed when cold may cause the pump to fail to pick up, whereas, if the pump picks up with the motor cold the increased speed when the motor is hot may overload it. This peculiarity should be recognized and suitable provision made for it either in the pump itself or in a device by which the speed of the motor can be changed slightly.

Between no load and full load the ordinary shunt motor without interpoles will drop from 1 to 5 per cent. in speed. With interpoles the drop can be practically eliminated or the speed even increased slightly under load. With a variation in line voltage the speed of the motor varies proportionately to the voltage, but not directly so. For instance, with a motor running on 230 volts, a drop in voltage to 220 volts will not cause the speed to be $\frac{220}{230}$ or 95.5 per cent. of what it was at 230 volts, but the drop in speed will be about 70 per cent. of the voltage drop, or, in this case, the drop in speed will be $(110 - 95.5) \times 0.70 = 3$ per cent., approximately.

Series Motors

Series motors are nearly all used with hand control, where the operator can watch the work, as the speed varies widely under load depending upon the torque demanded and if the load is thrown off the motor will run away. The application of a series-wound motor is usually very special. In general, the placing of a series winding on a shunt motor makes the speed vary widely under load, so that if heavy starting torque is essential, and inherent speed regulation is desired after the motor is operating, the series winding must be cut out after the motor is up to speed.

For variable-speed work the direct-current motor is preeminent. Speed control can be obtained by the insertion of resistance in series with the motor, this armature resistance producing a reduction in speed with constant torque. The objections to this method of control as regards unstable speed as the load varies, the size of control equipment and poor economy are the same as mentioned under the variable-speed, alternating-current wound-rotor motor with resistance in the secondary circuit. By varying the field resistance, however, a constant horsepower, variable torque motor is produced with speed variations as high as six to one. At any given speed the drop from no load to full load is very slight.

The characteristics of an adjustable speed motor, aside from the speed features, are similar to the nonadjustable type. The horsepower rating of the motor is usually the same at all speeds. This, however, may not be strictly true as at the lowest speed the rating may have to be decreased due to the poorer ventilation and consequently greater heating. In applying an adjustable speed motor it should be remembered that the size and consequently the cost are directly dependent on the horsepower developed at the lowest speed. For instance, suppose the application requires a 5-hp. motor with a speed range of from 300 to 1200 r.p.m. This motor must, of course, be large enough to develop its rated horsepower at the lowest speed of 300 r.p.m. If, however, the speed range could be decreased from 300 to 1200 the motor would only have to develop its rating at 300 r.p.m. or would need to be approximately only $\frac{2}{3}$ as large. In many applications the motor runs at the lowest speeds only very intermittently and the horsepower required is less than that at higher speeds. In such cases a very considerable saving in first cost and size of motor can often be made by using field control down to a certain point and armature control for the lowest speeds.

There are several other methods of obtaining adjustable speed in motors, but the field-control method is the most widely used and probably the best for most installations. Multiple-voltage systems where different voltages can be applied to the motor can be utilized in some cases, but usually only one voltage is available.

Comparing the direct-current motor with the multiphase-induction type, the former, for constant-speed work, possesses the great disadvantage of a commutator with constant attention necessary. Therefore, wherever possible to use it, the multiphase-induction motor is preferable on account of simplicity and less liability to give trouble. Where adjustable speed is required, however, the direct-current motor is by far the better.

Applications

Wherever possible, wood-working machines should be driven by alternating-current, squirrel-cage motors. The principal reasons for this are because of the inflammable nature of the material; the direct-current open motor with sparking commutator might be a serious risk because of the large amount of dust and dirt which is always present. There is an additional reason in that wood-working machines are inherently high speed and practically all constant speed, so that a high-speed induction motor is particularly applicable, whereas the same speed on a direct-current motor might cause commutation troubles. Where direct-current motors must be used they should be totally inclosed and compound wound, because under the fluctuating load which occurs with every wood-working machine while it is running under load, compound-wound motors give better service than shunt wound.

Metal-working Machinery

In the case of the metal-working machinery the conditions differ so that no one type of motor can be said to be best suited to all conditions. Dust and dirt are not so prevalent as in wood-working plants and the materials used are not inflammable. The question as to the proper type of motor, therefore, depends largely upon local conditions. Where the tools are small and group driven and where the speeds are not changed frequently, the induction motor offers the advantages previously set forth—simplicity and ruggedness. However, there are many tools, such as large lathes, where the speed is frequently changed and where the output depends largely on the facility with which the operator can adjust the speed to meet the conditions. In such cases the direct-current, adjustable-speed motor is best.

With lathes, boring mills, drills and similar machinery, shunt-wound, direct-current motors and squirrel-cage, alternating-current motors are satisfactory. With planers, rolls, bulldozers, etc., compound-wound motors are more satisfactory if direct current is used and wound-rotor motors if alternating current. With planers, where the horsepower for reversing is much greater than for the actual cutting stroke and for punches, presses and similar machines where violent overloads occur a flywheel should be installed wherever possible.

Pumps

For present purposes pumps may be divided into reciprocating and centrifugal types. In the former the amount of water pumped per revolution of the crankshaft is constant, barring slippage, being due to the positive displacement of the water by a plunger or piston. Any increase in pressure increases directly the work to be done. Where alternating current is used a wound-rotor motor is preferable, where the motor starts under load, and a compound-wound motor where direct current is used.

Rotary pumps are of comparatively small size and may be classed as reciprocating pumps so far as motor application is concerned as they produce a positive displacement of the fluid by means of rotating cams.

In centrifugal or turbine pumps the pressure developed is proportional, theoretically, to the square of the speed, and the volume of water discharged is proportional to the speed; hence the horsepower required varies as the cube of the speed. A reduction in head tends to overload the motor and with some types of pumps the breaking of a discharge pipe close to the pump, for instance, would overload the motor dangerously. A motor to drive a centrifugal pump, therefore, should be large enough to take care of any load thrown upon it by an increase in speed or a decrease in head, and should be protected, either by some protective device or by the design of the pump itself, from excessive overload if the discharge line breaks. Centrifugal pumps require low starting torque and even when running with discharge valve closed require only about 35 per cent. of normal power.

Fans, Blowers and Compressors

Fans are more or less like centrifugal pumps in their action in regard to power requirements. As the head is decreased the power increases, and similarly as the speed increases the power required goes up as the cube of the speed. Hence, it is important to make sure that the operating conditions are thoroughly understood and that the motor is of the proper size. Speed regulation, as in the case of centrifugal pumps, is also important.

Some blowers produce their pressure by means of rotating cams so that their behavior is unlike that of fans since the volume displaced per revolution is fixed regardless of the pressure. Any decrease in pressure decreases the load and *vice versa*. Both fans and blowers start without load.

Compressors of the reciprocating type present no especial difficulty in applying motor drive. Large compressors are often driven direct by synchronous motors with the rotor pressed direct on compressor shaft. In this case the compressor is provided with some form of bypass or unloading device so that no trouble is experienced in starting.

While cases might be multiplied indefinitely showing the application of motors to certain types of machinery yet the foregoing illustrate the way in which these requirements vary, due to the character of the work. In attacking any motor-drive problem the first essential is to know the individual peculiarities of the driven machines, how they operate and just what will be expected of them. The question as to kind of current is determined not only by the machine itself but by the conditions existing at the plant, whether current is to be purchased or generated and whether a choice is available or the kind of current is fixed. From the general conditions of the plant a choice can usually be made as to the general type of motor to install. Then each individual motor drive should be taken up as a separate problem so far as possible. The estimate first made may have to be modified as the work progresses or additional data are given. While it is absolutely essential that a motor should be amply large to handle the work, yet if it is too large the operating efficiency is lower, the first cost greater than it should be and in the case of alternating current the power factor is lowered; hence overmotoring is to be avoided. Furthermore, no matter how well the motor is adapted for the work, it must be properly installed and properly cared for after installation or it will not give satisfaction.

The machinery building of the Panama-Pacific exposition, at San Francisco, Calif., which was put under construction on Jan. 1, 1913, will be the largest frame building in the world, according to its architect, Clarence Ward. It will require 8,000,000 ft. of lumber, it is stated.

Handy Wiring Computer

Electrical engineers and wiremen will appreciate a handy wiring computer which is being furnished free upon request by the Simplex Wire & Cable Co., of 201 Devonshire St., Boston.

The computer is mounted on stiff, thick celluloid of a convenient pocket size, and consists of a circular slide rule particularly adapted for wiring calculations.

The size of a wire, B. & S. gage, is readily determined by setting the disk to correspond to a given distance of distribution for a desired voltage drop and the current which the wire is to carry; or given the size, B. & S. gage, the current to be carried and the distance of transmission may be found. The resulting voltage drop may be read directly upon the computer. In like manner, the current may be found at one setting for a desired voltage drop with a definite sized wire and distance of transmission. Finally, the distance to correspond to specific conditions of voltage drop, the current, and size of wire may be found by a single setting of the disk. The setting of the disk is very simple and directions for attaining these four different results are given explicitly at the foot of the card. Much laborious figuring is thus avoided by its use. On the reverse side of the pocket card are handy tables of wiring data and a table of decimal equivalents of fractions of an inch.

Reversed Polarity

I was interested in the account of a reversal of polarity, by Mr. Gibbeney in the Jan. 14 issue. No mention was made, however, of the kind of field employed or the nature of the load at the time.

As the machines were not running in multiple and it does not seem from the account that any switch or circuit-breaker had been so suddenly opened as to cause reversal by induction, I assume the generator to have been carrying a motor load and that it had series or heavily compounded fields, possibly running at the time with considerable resistance cut in the shunt field circuit. Under either of these conditions the following explanation, in conjunction with the two diagrams, would explain one likely cause of such a reversal.

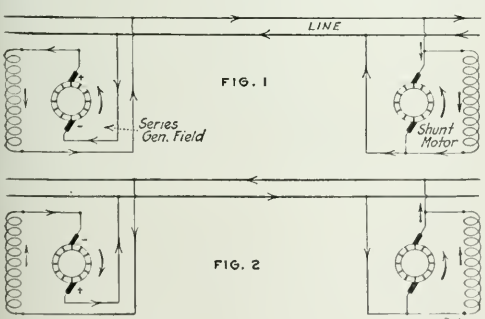


Fig. 1 shows a series generator or the series winding of a compound-wound generator, connected to a shunt-wound motor. Granted a sudden decrease in the speed of the engine as stated, if the nature of the load was such that the momentum of the machines carried the motors over a few revolutions as a generator (say street-car or elevator service), the motors acting as generators would send a current in the reverse direction to the generator and reverse the direction of magnetism in the field and the generator would act momentarily as a motor against the pull of the engine.

It will be noticed from the diagrams that the direction of magnetism in the motor field is not reversed, as would be the case if the reversal of polarity was caused primarily by the generator.

I would like to hear whether the conditions were as assumed in regard to the windings and load.

William C. Thorne.

Wineland, N. J.

Voltage across a Lamp

A statement that seems to be believed by many is that when either two 110-volt lamps are placed in series across a 220-volt circuit or five in series on 550 volts, if one of the lamps is removed and something else substituted in its place there will still be 110 volts across whatever has replaced the lamp, no matter what its resistance may be.

The writer once heard such an argument between a dynamo tender, who knew better, and a repairman who did not. They were working in an electric-railway power station, the voltage was about 550. Nevertheless, the repairman insisted that if he removed one of the lamps from a cluster of five in series and himself bridged the gap he would get a shock from only 110 volts.

The dynamo man did not agree with him but was willing to let him make the experiment. The repairman removed one lamp and took hold of the ends of the wires, but dropped them much more quickly than he had taken hold of them, at the same time being nearly knocked to the floor. After that he was willing to believe that the voltage between two portions of a series circuit might vary.

However, there are many who are mistaken on this point. A little thought on the subject, however, will convince anyone that the voltage drop across the different parts of a circuit will vary as the resistance of these parts, and when a man interposes the high resistance of his body between other parts of the circuit made up of comparatively low resistance units he will get the greater part of the drop, and in consquence a much more severe shock than he expected.

The same mistake is often made when an attempt is made to burn incandescent lamps of different resistances, but designed for the same voltage, in series with one another. This happens not only when two new lamps of different candlepower or of the same candlepower but different watts per candlepower are placed in series, but also when a new lamp is placed in series with an old one marked exactly the same. The reason for the trouble in the last instance is that as a lamp gets older and has burned many hours, its resistance changes.

Whatever the cause of the difference in resistance the result will always be the same—the lamp with the higher resistance will get more than its share of the voltage across its terminals and will burn out sooner than would have been the case if all of the lamps had been of the same resistance.

Brooklyn, N. Y. G. H. McKelway.

GAS POWER DEPARTMENT

Observations on the Oil Engine

By John F. Wentworth

In the early days of the internal-combustion engine, illuminating gas was the sole fuel. Although patents in this line date back as early as 1794, the first engine of this type built and run successfully was the Lenoir (1860), which was run like a steam engine. Gas vapor or a mixture of gas and air was admitted for a part of the stroke and then exploded, the expansion of the working charge taking place during the remainder of the stroke. This engine had a very poor economy and was simply an endeavor to apply the explosive-gas idea to the ordinary steam-engine principle.

The next step in the internal-combustion engine was a step backward on the track of the steam engine to the first type built or to the atmospheric engine. This was known as the "free piston" type. There were at least two engines of this kind built—one by Otto and Langen, in Germany (1867), and the other by Barsanti and Matteucci, in Italy, the former apparently the more successful. Substantially, a charge of air and gas was exploded under a piston in a long water-jacketed cylinder and the force of the explosion propelled the piston upward. The gas expanded to below atmospheric pressure, due to the combined effect of the momentum of the piston and the rapid cooling of the gases caused by their sudden expansion. Upon the return stroke the piston did its work by an ingenious arrangement whereby the rack carried by the piston was thrown into mesh with a pinion upon the shaft. This engine worked, but was too noisy.

Otto next produced the internal-combustion engine in its present form of the four-stroke cycle. Owing to absence from the noise of the rack and pinion this engine was first known as the "Otto Silent."

The distillation of gasoline in the production of kerosene oil, and the fact that gasoline was easily vaporized to form an explosive, led to the use of a carburetor producing an explosive mixture of air and gasoline vapor in place of the mixture of gas and air. This type of engine soon developed to such an extent that what was an almost valueless byproduct from the production of kerosene has now become so valuable as to almost make kerosene the byproduct from the production of gasoline. George B. Brayton was one of the first to foresee this condition of affairs and began to work upon a form of engine in which crude oil could be used for fuel. He and his coworkers attempted to form a mixture of air and oil and treat it in a manner similar to the way in which the gasoline and air was treated, but with poor success. Endeavors have been made to treat the crude oil with heat to vaporize it and form an explosive mixture, but these attempts have all failed, owing to the presence of a nonvolatile portion of the crude oil, which forms a tar and clogs the vaporizing element after the engine has been run a short time. Before the time of Diesel, Brayton had an engine in which the oil was mixed with a jet of air and driven into the cylinder at the end of the compression stroke. It was supposed to be ignited by a sort of burner maintained within the combustion chamber. This burner was fed with oil and had a coil of platinum wire. While some arrangement of this sort might work for a while, it was bound to sooner or later become foul. Had Brayton known of or used the de Rochas cycle with its ignition by the temperature of compression, he would have had no trouble with ignition and Diesel might never have been heard of.

Rudolph Diesel in 1891 applied for a patent in this country, on his now famous engine. He was at first carried away with the idea of preventing the loss of heat by the water jacket. The writer knows how easy it is to fall for this idea because he spent much time and money along similar lines. He hoped to gain by cutting out the water jacket loss and using this energy to heat a larger volume of air, and it was hard to see how anything was lost. It is now clear to the writer, however, without the aid of mathematics; the adiabatic line is the hill. By compression the height of the hill was increased without a change of conditions, for theoretically all that is lost by compression is got back by expansion. This adiabatic line is a smooth curve without a break reaching infinity volume and absolute zero. If heat is added to the substance it is equivalent to adding a layer to this curve, but to get 100 per cent. efficiency all the energy of this layer must be collected even to absolute zero. This type of engine which the writer was working on would be fairly efficient at low pressure.

Dr. Diesel did not fail in his thermodynamics, but he did even worse—he did not take into consideration the loss in mechanical efficiency due to the compression of the air. His engine in mechanical construction was identical with the Brayton engine except that he left off the flame ignition and in its place he followed the principles laid down by de Rochas in 1862. To quote from Dugald Clerk, the operation proposed by de Rochas was as follows:

1. Suction during the entire out stroke of the piston.
2. Compression during the following instroke.
3. Ignition at the dead point and expansion during the third stroke.
4. Forcing out the burned gases from the cylinder on the fourth stroke.

The ignition he proposed to accomplish by the increase of temperature due to compression.

In addition to applying the principle of de Rochas to the Brayton structure, Diesel proposed to eliminate the water jacket and to feed his fuel in such small quantities as to prevent an essential increase in pressure or temperature.

In U. S. Letters of Patent No. 542,846, issued to Rudolph Diesel, July 16, 1895, is found the following:

> According to what has been above stated, the process of combustion itself differs from all the hitherto methods, in that there is no increase of temperature produced, or at the most only a very slight one, and the highest or extreme temperature is produced by the compression of the air. It is therefore under control and will be kept within moderate

limits, and moreover, in view of the cooling of the products of combustion by the subsequent expansion, no artificial cooling is required for the cylinder, the mean temperature of the gases being such that the parts of the engine can be kept tight and lubricated.

In Fig. 1 the diagram *ABCDEA* is from the actual Diesel engine, which has the record of the highest efficiency for any engine ever built with the possible ex-

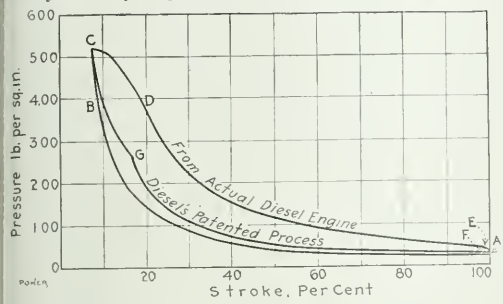


Fig. 1. Actual Diesel Diagram Compared with That Drawn According to Patented Process

ception of the Banki motor. Diagram *ABCGFA* is plotted according to the patent process. The line *ABC* is the adiabatic compression line; *CG* is the isothermal expansion line and *GF* is the adiabatic expansion line. The feeding of the fuel continues from *C* to *G* at a rate such that there is no essential increase in temperature. By a comparison of the tests published on the Diesel engine as actually run, it becomes evident that the patented process of Dr. Diesel would not give power enough to run the engine. This is so on account of the loss in

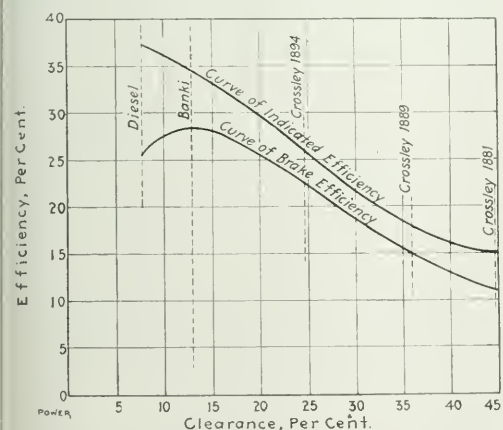


Fig. 2. Brake and Indicated Efficiencies of Different Engines

compressing the air. This ideal diagram (*ABCGFA*) would have a fair theoretical efficiency, but no practical efficiency.

This patented process is disclosed by Claim 1 of the above mentioned letters of patent. The claim reads:

The herein described process is for converting the heat energy of fuel into work, consisting in first compressing air, or a mixture of air and neutral gas or vapor, to a degree of producing a temperature above the ignition point of the fuel to be consumed, then gradually introducing the fuel for combustion into the compressed air while expanding against resistance sufficiently to prevent an essential increase of temperature or pressure, then discontinuing the supply of fuel and further expanding without transfer of heat.

This is the only process to which Diesel can lay claim as far as the writer can find out. All other patents are combination patents and the best practically copy the Brayton construction.

Sargent originated a method for governing gas engines in which the amount of air was varied to agree with the load as well as to vary the fuel. In the de Rochas cycle and its modifications the ignition of the fuel is controlled or brought about by the temperature resulting from compression aided in some cases by a heated projection in the combustion chamber. In all cases the design of the engine gives compression sufficient to obtain ignition of the fuel. Now if the amount of air is cut down when the load is lowered, ignition will not take

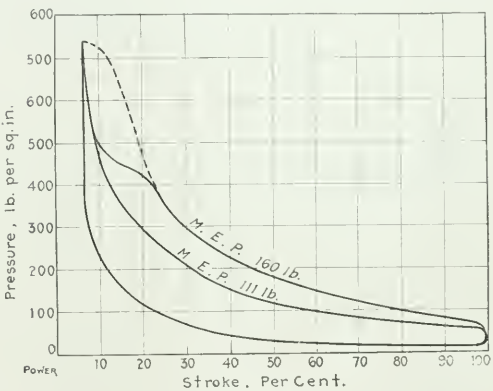


Fig. 3. Diagram from Wentworth Engine

place. Compression of unnecessary air means a loss in mechanical efficiency or the mechanical efficiency of the de Rochas cycle falls off far more at low loads than does the mechanical efficiency of gas engines under the same load.

Fig. 2 shows curves of brake and indicated efficiencies on different engines. The idea of these curves as originally worked up and plotted was to show the benefit of high compression. By running a series of tests on the same engine fitted with different heads so as to vary the clearance, more valuable results could be obtained than to compare different types of engines which had the required range in clearance. However, the curves show the benefit which has come from a development along the lines of a reduced clearance.

Fig. 3 is a diagram taken on the writer's experimental engine. This is not a commercial engine, as yet, and has been designed only for private experiments. There is one point which may or may not mean anything. It seemed to the writer that the Diesel engine was not using as much oil per pound of air as was possible and this diagram perhaps could be taken to verify this belief. The peculiar shape of the diagram may be explained as follows:

The pressure in the air line was about 750 lb. and the fuel was fed in earlier than in the Diesel engine; hence the explosion pressure jumped up so as to stop the

further injection of oil. Then as the charge of hot gases in the cylinder expanded, the pressure in the cylinder was lowered and the fuel was again fed into the cylinder before the fuel valve closed. Whatever the cause was, in the experimental engine a mean effective pressure was obtained about 50 per cent. higher than in the Diesel engine. In fairness to the Diesel engine it is reasonable

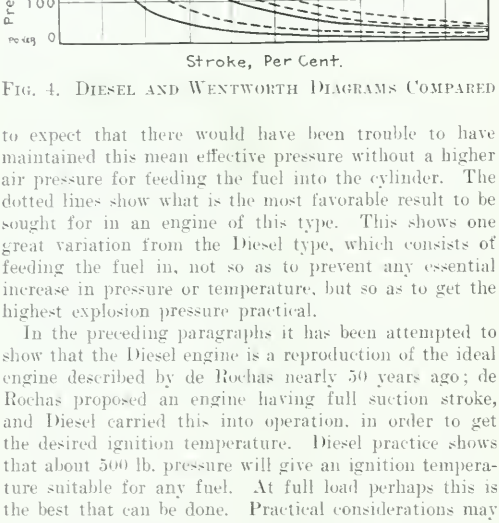


Fig. 4. Diesel and Wentworth Diagrams Compared

to expect that there would have been trouble to have maintained this mean effective pressure without a higher air pressure for feeding the fuel into the cylinder. The dotted lines show what is the most favorable result to be sought for in an engine of this type. This shows one great variation from the Diesel type, which consists of feeding the fuel in, not so as to prevent any essential increase in pressure or temperature, but so as to get the highest explosion pressure practical.

In the preceding paragraphs it has been attempted to show that the Diesel engine is a reproduction of the ideal engine described by de Rochas nearly 50 years ago; de Rochas proposed an engine having full suction stroke, and Diesel carried this into operation, in order to get the desired ignition temperature. Diesel practice shows that about 500 lb. pressure will give an ignition temperature suitable for any fuel. At full load perhaps this is the best that can be done. Practical considerations may make it advisable to refrain from using a pressure of over 500 lb. per sq.in. in the cylinder. The main point of the writer's work has been to produce a crude-oil engine in which an ignition temperature of suitable amount can be obtained with a full cylinder of air or a partial cylinder of air.

The Diesel engine is supposed to operate in any temperature, but the writer has never seen anything relative to the climate in which it can be used. If the Diesel engine has a temperature of compression of 1000 deg. F. with outside air at 60 deg. F. (which temperature is satisfactory), if operated with the outside air at 120 deg. F. the temperature of compression would be 1100 deg. F. or at least 100 deg. more than is required. Likewise, if the intake air should drop to 0 deg. F., the temperature of compression would drop to 885 deg. F.

The Wentworth engine is different from the Diesel in that provision is made for heating the incoming air before compression. If this is done with intelligence it is possible to have the temperature of compression correct and to have the proportion of fuel to air constant at all loads. The Diesel engine governs by varying the fuel only; the Wentworth engine by varying the fuel and air so as to keep the mixture constant and in order to have, at 250 lb. pressure of compression, the same temperature which is had at 500 lb. pressure, heat is added to the incoming air.

Fig. 4 shows a full-load and partial-load diagram from the Diesel engine, shown dotted, and the solid line is a partial-load diagram as is sought in the Wentworth engine. The full-load diagram of the Wentworth engine would lie somewhere between the full-load Diesel diagram and that shown in Fig. 3. The advantage of the Wentworth engine over the Diesel or any other engine which governs by a reduction of the fuel alone or by varying the proportions of the mixture is shown in Fig. 5. Here curves are drawn by laying off at regular intervals the pressure per square inch on the piston for every 36 deg. revolution of the crankshaft. This shows that the Diesel engine at two-thirds load would have an average pressure on its bearings, due to 145 lb. per sq.in. in the cylinder. The Wentworth engine developing the same power would have a pressure on its bearing from but 98 lb. per sq.in. pressure in the cylinder. This would show a saving on the main bearings of 33 per cent. In this method of treating the subject, which is simple and graphic, no allowance is made for the effect of the reciprocating parts. At the same speed the two engines would have the same pressure on the bearings from this source.

At partial load the Wentworth engine is virtually a compound engine. On the compression stroke but two-thirds or three-quarters of a cylinderful of air would be compressed, while on the expansion or working stroke the expansion would be carried out the full stroke. Assuming that the engine was running on two-thirds power or that two-thirds the amount of both fuel and air was used, the effect of compounding would be equivalent to the present Diesel engine compressing its charge in a cylinder of 28 in. diameter and expanding in a cylinder of 35¾ in. diameter. This gain in the theoretical efficiency can be obtained without any loss whatsoever. Op-

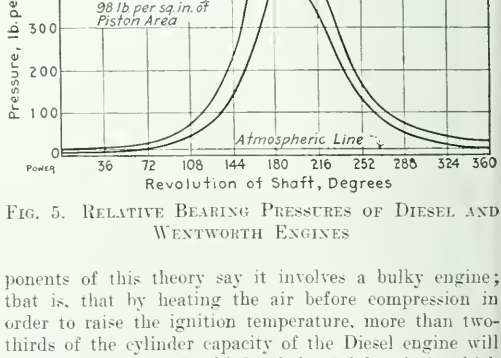


Fig. 5. Relative Bearing Pressures of Diesel and Wentworth Engines

ponents of this theory say it involves a bulky engine; that is, that by heating the air before compression in order to raise the ignition temperature, more than two-thirds of the cylinder capacity of the Diesel engine will be required to get two-thirds of the weight of air which the Diesel engine uses at full load. This is true only when the engine is running light; however, the writer has it on authority that the Diesel engine can run on a reduced compression after the engine becomes warmed, or in other words, compresses to a higher pressure than is needed after the engine gets started. In the Went-

worth engine by a regulation of the temperature unnecessary compression can be saved.

The recommended Wentworth cycle is as follows:

1. Addition of heat to the incoming air to give a temperature such that when the desired compression pressure has been reached ignition will be possible by the simple injection of the fuel.
2. Suction for that part of the suction stroke which will compare with the load upon the engine.
3. A full compression stroke.
4. Ignition to be obtained by injection of the fuel. (In light loads this injection of the fuel will be advanced in order to give a higher pressure of explosion.)
5. A full expansion stroke.
6. A full exhaust stroke.

Lubrication of Gas Engine Cylinders

In reading the article on the above subject in the Jan. 28 issue, by A. L. Brennan, Jr., I found several passages which are not clear to me, and others with which I cannot agree.

It is stated that there are three important points to be considered in the lubrication of a gas-engine cylinder; these three qualities of the lubricating oil being a flash point of 390 to 450 deg. F., a specific gravity of from 26 to 30 Bé., and a viscosity ranging from 180 to 220 at 80 deg. F. According to Mr. Brennan, viscosity is made up of two properties; cohesion and adhesion. He says the former "is that property of the oil that binds its particles together," and that "adhesion is that clinging property which causes it to adhere to other bodies." It may be that the viscosity of an oil is made up of two, or maybe twenty properties, but it is usually measured by noting the time taken for a given quantity of oil to run through a given size aperture in an instrument which is usually known as a viscosimeter. It is really a measure of its fluidity. Mercury, for instance, has a very low viscosity, but relative to many bodies, no adhesion.

No general rules or principles can be laid down which can be applied to all types and sizes of gas-engine cylinders. Lubrication of small gas and gasoline-engine cylinders, such as used in automobiles and motor boats, is a comparatively simple matter, and, even though an oversupply of lubrication fouls the cylinders, the cleaning of them is comparatively easy. When it comes to large cylinders and especially large cylinders in a horizontal position, the problem is vastly different. I am quite sure that Mr. Brennan had not the latter condition in mind, but the lubrication of large horizontal cylinders presents the real problem in gas-engine lubrication. Moreover, I am convinced that some of the cheapest oils I have purchased and used (18c. per gal.) have proved as effective and satisfactory for lubricating large gas-engine cylinders as any others.

The qualities of any mineral oil under high temperatures are vastly different than at ordinary temperatures and pressures, such as that of the atmosphere in which they are tested, and indeed all mineral oils approach each other in physical characteristics at high temperatures. It has been conclusively shown that out of over 200 oils tested, ranging in specific gravity from 0.887 to 0.926, some of which were too thick to flow at 70 deg. F., and having viscosities ranging from 58 to 312 at 212 deg. F., nearly all of them had the same viscosity at temperatures above 500 deg. F. The flash points of these oils ranged from 288 deg. F. to 622 deg. F. These tests show, that with the conditions under which most oils operate in a gas-engine cylinder, if temperatures alone are considered, they all have practically the same viscosity.

Nobody knows just what the physical action is which takes place during processes of lubricating a gas-engine cylinder. It is pretty generally supposed that the condition which makes lubrication possible is the comparatively low temperature of the cylinder walls and the piston. It must be evident that any combustible which is in a cylinder during an explosion stroke, is at least partially burned. If the interior surface of the cylinder walls and the head of the piston is at such a temperature that combustion on the surface is quenched, then any oil that may be on this surface may be partially burned. That portion of the oil which is not burned in the combustion space is, however, usually incombustible matter. It is important that the oil should contain no incombustible matter if the cylinder is to be kept as free from carbon as possible. It is expected that some oil may find its way into the combustion space, but it is the hope of most operators that such oil will burn up without depositing on the walls.

The splash system of lubrication is a "makeshift" in anything but small motors, in which it may be used quite effectively. The lubrication of large cylinders is usually done by timing the delivery of the lubricant under pressure so that it enters between the rings on the piston.

Mr. Brennan says that "the first indications in the case of using a poor oil are manifest in decreased power, due primarily to the friction offered the surfaces of the piston and cylinder, secondly, to faulty compression, due to the piston rings becoming inoperative, and thirdly, to carbon deposits, which materially reduce the efficiency of the valves and impair the function of the spark plug."

Unless an engine is staggering under all the load it can carry, I have yet to see one in which I could discover a case of improper cylinder lubrication by a decrease in the power developed. Usually the governor will open up and allow the engine to pull all the load demanded unless some other conditions than faulty lubrication exist; such, for instance, as weak gas, missed ignition, etc. I am convinced that if cylinder lubrication were so much at fault that one could notice it by a decrease in power, there would be some smoke and probably the piston would seize before the keenest eye could discover a decreased power development.

Mr. Brennan is correct in saying that one of the most injurious effects of improper lubrication is the deposit around and under the piston rings, which soon renders them inoperative as spring rings and practically fastens them in their grooves. Such a condition is one of the most prolific causes of cut and scored cylinders. But in many such instances which I have seen, I am quite sure that the contributing cause is dirty gas.

I would appreciate being informed as to just what is meant by this sentence—"Poor lubricating oil not only impairs the mixture by a partial combustion of its own elements but by not keeping the wear at a minimum, allows lower compression which in turn puts greater demands upon the ignition current." Especially is it desirable to know how lower compression puts greater demand upon the ignition current.

New York City. L. L. Brewster.

REFRIGERATION DEPARTMENT

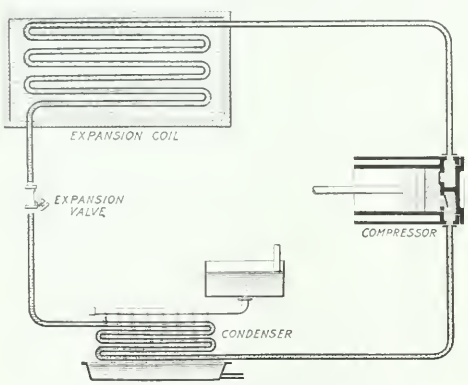
Refrigeration Made Simple

Refrigeration has been defined broadly as the process of cooling. A block of ice in the small refrigerator for home use is commonly supposed to cool down the interior of the box in which it is contained, and so it does, but instead of imparting cold to its surroundings, the cooling effect is obtained by the ice extracting heat from the air, the material of which the refrigerator is made and the food contained within. In doing this it melts, and when enough heat has been drawn from the refrigerator all of the ice will have been turned into water. Refrigeration then is the process of extracting heat, and will always take place when a cold body is in the presence of another at a higher temperature. If the hand is placed in a pail of water fresh from the well, a flow of heat will take place from the hand to the water. The hand will have lost the same amount of heat that the water has gained, and as it has been made colder, that is, as heat has been extracted from it, the hand has been refrigerated and the water is the refrigerant. Just as water will always flow from a higher to a lower level so will heat pass from any material to one of lower temperature. It is this action which makes refrigeration possible.

It is evident then that any material may refrigerate, provided that it is at a lower temperature than its surroundings. The water in a tubular boiler refrigerates the gases passing through the tubes, although it is not commonly thought of in this way, as it is usual to link refrigeration with lower temperatures.

There are a few materials, however, due to their peculiar properties, by which refrigeration may be more efficiently effected. Most prominent of these are ammonia, carbonic-acid gas and sulphur dioxide. Ammonia is more commonly used than the others and in two different types of apparatus, which collectively are known as the compression and absorption systems. Compression plants are much more numerous, and to understand their working, a comparison will be made with the ordinary steam plant with which all of us are familiar.

In the accompanying sketch a rough diagram of the steam plant is shown on one side and the compression system of refrigeration on the other. From the drawing it is easy to see that the two systems are similar. In fact, they are governed by the same laws, but the events in each cycle are in the opposite direction. To begin with, the water in the boiler is supplied with heat from the coal burning on the grate. Only one heat unit to a pound of water is required to raise the temperature 1 deg. F. As a consequence the rise in temperature is rapid until 212 deg., the boiling point at atmospheric pressure, is reached, when it appears to stop and no further rise may be noticed until 970 heat units, known as the latent heat of evaporation, have been added to every pound of water. When this heat has been absorbed the water turns into steam, and if the steam is not allowed to escape the pressure will rise. The minute that pressure is developed a funny thing happens. The boiling point of the water is no longer at 212 deg., but at some temperature corresponding to the pressure. If the pressure were 150-lb. gage, the water would boil, or, in other words, evaporate, at 366 deg., and the latent heat would be reduced to 857 heat units. Any temperature below 366 deg. would condense the steam.



Ammonia Compression System

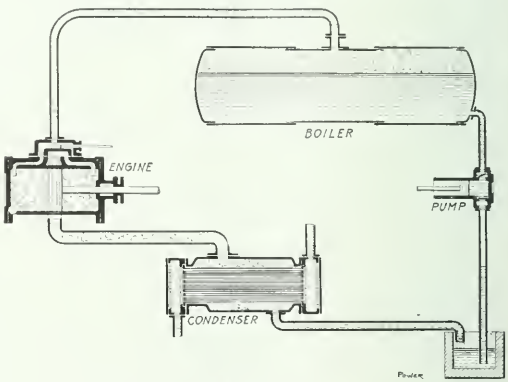


Diagram of Condensing Steam Plant

From the boiler the steam passes to the engine, where it expands and gives up some of its energy in the form of work. Passing on to the condenser enough cooling water is supplied to condense the steam, and the water of condensation is returned by means of a pump to the boiler. This pump requires a certain amount of energy to drive it, and to obtain the most economical results the water should be returned to the boiler as hot as possible.

In the refrigerating system we will start with the expansion coils, the part of the system corresponding to

the boiler. Here the liquid, the ammonia, is introduced and evaporated by the heat from its surroundings. If the ammonia coils are placed directly in the room to be cooled, the process is known as direct expansion, but if the coils are located in a brine tank and the brine circulates in the room we have the brine system. From the expansion coils the ammonia vapor is drawn into the compressor and instead of expanding and producing work, as in the steam engine, the vapor is compressed, which requires an expenditure of work. If the boiling point of ammonia at the expansion-coil pressure were at some temperature higher than the temperature of average cooling water, there would have been no need of the compressor. At atmospheric pressure the boiling point is 28 deg. below zero and cooling water is usually 60 deg. above and over. So it is necessary to compress the vapor to about 185 lb. pressure to raise its boiling point so there will be no difficulty in converting the vapor into liquid in the condenser, to which it passes from the compressor. Although generally of different construction, the ammonia condenser operates on the same principle as the steam condenser.

In its liquid state the ammonia passes from the condenser through a restricted opening, called the expansion valve, to the expansion coils. In an ideal system the expansion valve might be readily replaced by a cylinder so that the liquid in passing from a higher to a lower pressure would do work, and not require an expenditure of work as in the case of the steam pump. The temperature of the liquid should be as low as possible, which, it will be remembered, is a requirement just opposite to that in the steam system.

When the ammonia liquid now at a low pressure, usually about 16-lb. gage, enters the expansion coils in the refrigerator, it absorbs heat from the surrounding medium, and when each pound of liquid has absorbed 569 heat units the latent heat at the above given pressure, it is converted into a vapor and is ready to start over again on the cycle just described.

From what has been said it will be clear that the prime object of a steam plant is to obtain as much work as possible with the least expenditure of heat, while in the refrigerating system it is desired to absorb or rather dissipate as much heat as possible with the least expenditure of work.

If the latent heat of the ammonia were 950, as in steam at atmospheric pressure, it would be a better refrigerant, as per pound it would carry away more heat from the refrigerator. Thus high latent heat is desirable in a refrigerant. Another requirement is a low boiling point, as this must be lower than the temperature it is desired to maintain in the refrigerator. On the other hand, the boiling point should not be much lower than the refrigerator temperature, as the lower it is the more power it will take to compress the vapor and raise the boiling point to a temperature above that of the cooling water in the condenser.

Ammonia seems to meet these requirements with less than any other refrigerant. The most simple refrigerating plant imaginable would be a flask of ammonia, liquid immersed in a pail of brine which we will say has a temperature of 50 deg. As previously stated the boiling point of ammonia is 28 deg. below zero, so that the temperature of the brine will be 78 deg. higher. Consequently, the ammonia will immediately begin to boil and evaporate, drawing the necessary heat from the brine until its temperature approaches that of the boiling ammonia. The brine in turn would tend to absorb heat from the surrounding air, so to maintain a low temperature in the pail it would be necessary to replenish the flask and continue the evaporation of ammonia, allowing the vapor to escape to atmosphere as before. This would be all right if the supply of ammonia were inexhaustible and it were not an expensive product. Unfortunately, this is not the case and it is necessary to conserve the supply, using it over and over again in much the same way as boiler-feed water.

To reclaim the ammonia vapor and change it back into a liquid, the compressor and condenser are necessary, in fact, just such a system as outlined in the sketch. There are, of course, auxiliary apparatus required just as in a steam plant, but the main principles of operation are pictured. The details of an actual commercial plant may be given in a later issue.

Drinking Water Systems

By S. M. Weinthal.

To circulate pure, cold water through a large structure is not a new idea, as many hotels and buildings in large cities have been so equipped during recent years. From a sanitary and humanitarian standpoint, these drinking-water systems are a necessity and should be installed wherever the welfare of employees is considered.

Fig. 1 shows a typical layout of a drinking-water system as applied to a mill or factory; the arrows denoting the path of the water. The water may come from any available source, such as wells, springs, city lines, etc., and, if not deemed sufficiently pure, should be passed

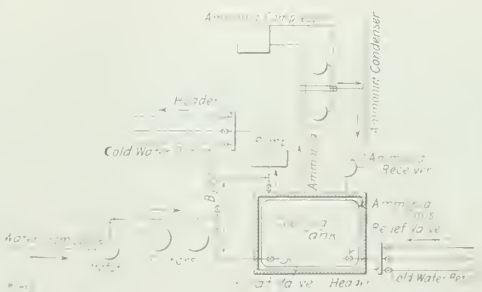


Fig. 1 Typical Layout of Water Cooling System

through a filtering process. It is then received into a storage tank, where it is cooled by contact with the surface of coils cooled by the direct expansion of ammonia, or the circulation of cold brine.

By means of a power-driven pump, the water is drawn from the tank and kept in rapid and constant circulation through the lines, which are arranged to make a complete circuit. These lines should be carried on trusses, hangers and columns and sloped in order to drain. They may issue from and return to headers which are directly connected to the tank and pump respectively. The water used is replaced automatically by water coming from the city

The maximum temperature from should not be greater

than 1500 ft. and the time consumed for the water to travel that distance should not exceed 30 min.; so as to minimize the loss of temperature, which, in that period, averages from 4 to 6 deg. F. if the lines are well insulated.

During the period of cold weather, when it is not necessary to cool the water, a bypass may be provided, as shown in the drawing, to enable the direct passage of the water into the lines. However, this is not advisable if applied at a low pressure, as it must be kept in rapid motion to prevent freezing.

that the most agreeable temperature of the drinking water is 45 deg. F. and the consumption of water per man per hour, including waste, during periods of extreme heat averages 0.3 gal. in factories and 0.4 gal. in mills. On this basis, a mill employing 1200 men would require 480 gal. per hour.

From the accompanying table the capacity of a refrigerating machine can be readily determined when the number of gallons to be consumed per hour has been fixed and the difference of the temperature is known.

CAPACITY OF REFRIGERATING MACHINES TO REDUCE TEMPERATURE OF WATER

Ice Melting Effect—Tons per 24 Hours

Reduction of Temp. Deg. F	Gallons of Water per Hour														
	1	50	100	150	200	250	300	350	400	500	600	700	800	900	1000
1	0.0007	0.035	0.069	0.104	0.139	0.174	0.208	0.243	0.278	0.347	0.417	0.486	0.556	0.625	0.695
5	0.0035	0.174	0.347	0.521	0.695	0.869	1.042	1.216	1.390	1.737	2.085	2.432	2.780	3.127	3.475
10	0.0070	0.347	0.695	1.042	1.390	1.737	2.085	2.432	2.780	3.475	4.170	4.865	5.560	6.255	6.950
15	0.0104	0.521	1.042	1.564	2.085	2.606	3.127	3.649	4.170	5.212	6.255	7.297	8.340	9.382	10.42
16	0.0111	0.556	1.112	1.668	2.224	2.780	3.336	3.892	4.448	5.560	6.672	7.784	8.896	10.01	11.12
17	0.0118	0.591	1.181	1.772	2.363	2.954	3.544	4.135	4.726	5.907	7.089	8.270	9.452	10.63	11.81
18	0.0125	0.625	1.251	1.876	2.502	3.127	3.753	4.378	5.004	6.255	7.506	8.757	10.01	11.26	12.51
19	0.0132	0.660	1.320	1.981	2.641	3.301	3.961	4.622	5.282	6.602	7.923	9.243	10.56	11.88	13.20
20	0.0139	0.695	1.390	2.085	2.780	3.475	4.170	4.865	5.560	6.950	8.340	9.730	11.12	12.51	13.90
21	0.0146	0.730	1.459	2.189	2.919	3.649	4.378	5.108	5.838	7.297	8.757	10.22	11.68	13.13	14.59
22	0.0153	0.764	1.529	2.293	3.058	3.822	4.587	5.351	6.116	7.645	9.174	10.70	12.23	13.76	15.29
23	0.0159	0.799	1.589	2.398	3.197	3.996	4.795	5.595	6.394	7.992	9.591	11.19	12.79	14.39	15.89
24	0.0167	0.834	1.668	2.502	3.336	4.170	5.004	5.838	6.672	8.340	10.01	11.68	13.34	15.01	16.68
25	0.0174	0.869	1.737	2.606	3.475	4.344	5.212	6.081	6.950	8.687	10.42	12.16	13.90	15.64	17.37
26	0.0181	0.903	1.807	2.710	3.614	4.517	5.421	6.324	7.228	9.035	10.84	12.65	14.46	16.26	18.07
27	0.0188	0.938	1.876	2.815	3.753	4.691	5.629	6.568	7.506	9.382	11.26	13.13	15.01	16.89	18.76
28	0.0195	0.973	1.946	2.919	3.892	4.865	5.838	6.811	7.784	9.730	11.68	13.62	15.57	17.51	19.46
29	0.0202	1.008	2.015	3.023	4.031	5.039	6.046	7.054	8.062	10.08	12.09	14.11	16.12	18.14	20.15
30	0.0208	1.042	2.085	3.127	4.170	5.212	6.255	7.297	8.340	10.42	12.51	14.59	16.68	18.76	20.85
31	0.0215	1.077	2.154	3.232	4.309	5.386	6.463	7.541	8.618	10.77	12.93	15.08	17.24	19.39	21.54
32	0.0222	1.112	2.224	3.336	4.448	5.560	6.672	7.784	8.896	11.12	13.34	15.57	17.79	20.02	22.24
33	0.0229	1.147	2.293	3.440	4.587	5.734	6.880	8.027	9.174	11.47	13.76	16.05	18.35	20.64	22.93
34	0.0236	1.181	2.363	3.544	4.726	5.907	7.089	8.270	9.452	11.81	14.18	16.54	18.90	21.27	23.63
35	0.0243	1.216	2.432	3.649	4.865	6.081	7.297	8.514	9.730	12.16	14.59	17.03	19.46	21.89	24.32

Pipe and fittings should be galvanized and insulated with cork 1½ in. thick, or some other covering of that equivalent. Long-radius ells or pipe bends should be used throughout to lessen the friction and, at points where it is desired to place a fountain, the connection should be as near the circuit as possible, so as to eliminate "dead ends." All waste water should flow directly into a sewer.

The refrigerating machine may be of the absorption or the compression type, the latter being generally used, due to the diversified manner in which it may be driven.

Investigation of some of the plants in operation shows

For example, suppose it is desired to know what size of refrigerating machine is necessary to cool 500 gal. of water per hour from 70 to 45 deg. F. The difference in temperature is 25 deg. In Column 500, opposite a reduction of temperature of 25 deg., read 8.687 tons ice-melting effect. The efficiency of the refrigerating machine will vary with the suction and condenser pressure; but, if these are maintained at the usual figures of 15 and 185 lb., respectively, it will lie between 75 and 80 per cent. Assuming 75 per cent. efficiency, the standard rating of the compressor would be 11.6, or, say, 12 tons.

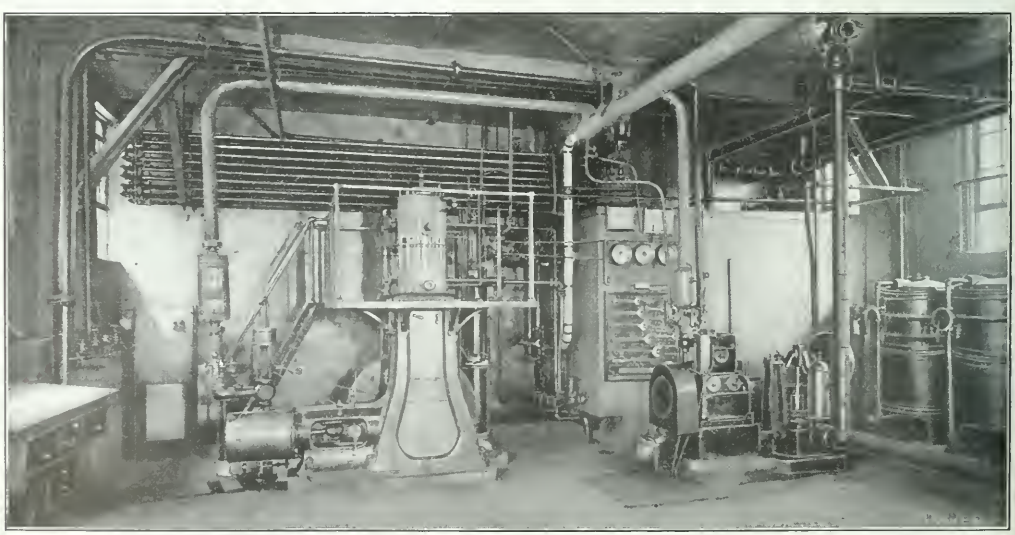


FIG. 2. TEN-TON PLANT AT CONTINENTAL WORKS OF NATIONAL TUBE CO., COOLING DRINKING WATER FOR 1500 MEN

EDITORIALS

In Massachusetts

Massachusetts has the distinction of having adopted the most comprehensive and far-reaching measures controlling boiler inspection and the licensing of engineers. So generally have these laws been approved, that Ohio took them as a pattern for its own laws and all states since and now contemplating legislation along similar lines are closely studying the Massachusetts enactments.

That there is need of state supervision in the matter of the sort of steam-generating equipment that shall be permitted to operate and the character of men allowed to have charge of steam plants, is beyond question. Safety of the public alone is a sufficient consideration, and if they could all only realize it, as some of them do, it is quite as much to the interest of owners and operators that the state shall require all possible precaution against power-plant accidents.

An owner who, unwittingly or from false ideas of economy, would maintain an unsafe boiler or employ an incompetent engineer, should be protected from his own ignorance or folly. The same is true of any engineer, who, lacking laws to prevent, might be required to use an unsafe boiler, or be tempted to take charge of equipment he was unqualified to handle. Generally, it is the very ones most benefited who are the most active in opposing the adoption of laws, and, failing in that, their enforcement. For all the world like a headstrong child, they rebel against the discipline that is for their own best good. And such is the case in Massachusetts if the newspaper reports are authentic.

A representative of the legislature, with more thought for votes than for the value of human life and property, is seeking popular favor by introducing a bill to set aside the requirement that a first-class engineer be employed to operate plants of more than 1400 horsepower. He would have second-class men or those with special licenses take charge of such plants.

Equally misguided are those in another part of the state who have complained of a state boiler inspector who took his duties seriously and, believing that laws were meant to be enforced, was so untactful as to swear out warrants for the arrest of violators of the inspection law. The whine is that his prosecution is persecution, and it is said the inspector has had a tip from "higher up," that, if he desires to remain in his present capacity, it would be wise for him to be more moderate in the enforcement of the laws.

Without knowing the details, it may be granted as conceivable that the inspector is abusing his authority. Some public officials have taken advantage of their power to serve their own ends. It is hardly likely in this case that graft could be the motive or the "persecuted" parties would not have had to go "higher up." Moreover, the newspaper account states, "in most cases the courts have found in his (the inspector's) favor." The account further states that the inspector was threatened by those he prosecuted that influence would be brought to bear to have him removed from the position. We rejoice that thus far he has not been intimidated.

It is unfortunate that the papers printing the reports referred to have such headings as, in the first case, "Measure to Help Engineers," and, the second, "May Trim Sails of the Boiler Inspector." The first looks like deliberate misrepresentation in behalf of the local plants that would like to have cheaper engineers and the second is similarly partisan.

Fortunately, the bias of the daily press is likely to have little effect. The important thing is for the State of Massachusetts to remember that the eyes of the country are upon it and its responsibility is great. Failure of the laws initiated by that state will be of very far-reaching effect and mean a setback to legislation contemplated in many other states. Now, would seem the propitious moment for all engineers' associations to express themselves by resolutions and official letters where they will do the most good, urging that no part of the present laws be repealed, but that all parts be strictly enforced, for, otherwise, the best law is useless.

Steam Stuff

Some weeks ago we called attention to the desirability of a generic term for the working fluid of a steam engine. H_2O, with which the engine is operated, may come into it as superheated steam, and be exhausted as a mixture of some eighty to ninety per cent. steam, and ten to twenty per cent. water. Our editorial set forth that one could not properly speak of this operating fluid as steam, when it was part water, and it is frequently necessary to make the distinction. We enumerated the terms such as "steam stuff," "working mixture," "operating fluid," "medium," etc., which have been applied to it, and asked for suggestions for a concrete and comprehensive generic name for the stuff.

The readers of POWER are always ready to take a shy at anything, even at language building. Several suggestions have been already published in our correspondence columns. A letter before us suggests as especially helpful, if adopted, to the European people, the euphonic term "venavivacqua," which being interpreted means "a vena with life and water," or "vaporpartevivo," which signifies in the language of sunny Italy, "vapor partly alive."

Another contestant has gone to the Greeks for his, and evolved the cognomen "hydrotherm." He explains that steam may be superheated, dry saturated or wet; there may be moisture present with superheated steam and with saturated steam, there may be also entrained moisture, which is not actually mixed with the steam; that any case when analyzed is bound to be nothing more than heated water, and that the term "hydrotherm" covers each and everyone of the states of condition of water and steam.

Another suggests that it be called "fog" or "vaporol."

Still another correspondent, looking over a copy of

Parker's "Natural and Experimental Philosophy," published in 1856, was struck with the statement that matter exists in four different states, namely, the solid, liquid, gaseous and the vesicular form. The latter seemed to be a specialty of Mr. Parker's, as most other authors stopped their enumeration of the states of matter with three. He defines it as that form of matter in which we see it in clouds. It consists of minute vesicles somewhat resembling bubbles, and it is the state into which many vapors pass before they assume a fluid condition. Water, for instance, is solid in the form of ice, fluid as water, in a gaseous state when converted into steam, and vesicular in the form of clouds. Our correspondent suggests that while the term "vesicular steam" cannot be considered as a name for the composition H_2O in all its conditions, it would be much more definite for designating the composition when in the condition referred to in the editorial than such inexpressive terms as "mixture," "steam stuff," etc.

An analysis of the last paragraph will reveal the need which we emphasize. Several lines above it is said, in the language of our correspondent and probably of the author whom he was quoting, "Water, for instance, is solid in the form of ice," etc. It is not, for when H_2O becomes ice it is no longer water. H_2O in its solid form is ice, in its liquid form water, in its vaporous or gaseous form steam. What we want is a word for the symbol H_2O in this expression simpler than the chemical name hydrogen-oxide.

Glenlyon Economizer Explosion

The coroner's jury in the case of the two men killed by the explosion of an economizer at the Glenlyon Dye Works, Saylesville, R. I. (see POWER, Jan. 28, page 136), has found that the two men "came to their death by accident and misfortune" without obtaining any additional light upon the cause and the manner of the disaster.

It is generally conceded that the explosion occurred in the section of the economizer which had been shut off for the renewal of one of its tubes. Water may have been left in the idle economizer or leaked back from the boilers or in from the feed pipe. With water in the economizer, an inoperative safety valve, and enough gases passing the dampers to even a little more than supply the convection and radiation losses, an explosion would be inevitable, and this is probably the way it occurred. There are those, however, who attribute it to an explosion of gas in the gas passage of the economizer, which had an aggregate volume of some 1800 cubic feet.

Such an explosion is possible, but there is a lack of information as to contributing circumstances to enable us to judge of its probability in this case.

If idle boilers or boilers with heavily banked fires were connected through the economizer it is possible that their furnaces, acting as producers, may have given off gas rich enough in carbon monoxide to produce an explosive mixture, but the coroner finds that "the firing of the boilers was no different than at other times."

It is probable that no definite and satisfying explanation of the cause will ever be found. The lesson to be learned is that water in an economizer subjected to heat will generate pressure and if the usual outlet to that pressure through the boiler is cut off, the pressure may increase to that corresponding with the temperature to which the water may become heated. When the economizer is in operation and connected to the boilers there is nothing for the safety valve to do, for if the pressure in the economizer gets to be greater than that in the boilers it will relieve itself into them. When this connection is closed there should be another positively open which will relieve any pressure which may be generated in the economizer. In case the economizer is to be laid off for inspection or repairs it should be drained of water and the blowoff valve and air vents left open. In order to avoid any possibility of an accumulation of gas in the gas passages the soot-pit doors and such other openings as are available should be left open to permit the free circulation of air.

With these simple precautions an economizer is nowhere nearly as likely to explode as is a boiler, as is evidenced by the remarkably few explosions which have occurred among the large number of economizers in use in all kinds of service.

The Average Owner

On page 350 we print a letter taking exception to our editorial on "The Average Owner," in the Dec. 31 issue. We feel it a duty to hold our columns wide open to the opinions of those who disagree with us, which is the principal reason we print the letter in question. Another reason is that we may hold it up as a horrible example of what we do not like to use, as explained in the editorial "Being Contented" in the Oct. 15, 1912, issue.

This is no reflection on the writer of the letter, for his views are probably justified by his experiences. We still believe, however, that the owner he pictures is the exception, not the average. We do congratulate Brother Robinson for having written one of the neatest gems of sarcasm and pessimism that we have read in a long time. While entirely disagreeing with his opinions, we thoroughly appreciated the letter judged as a piece of composition.

What Vacuum?

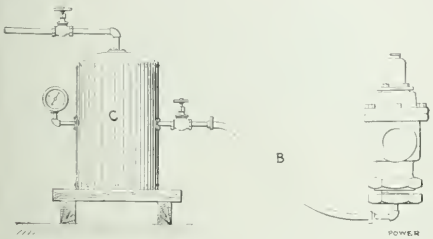
D. M. Morrison, the Scotch condenser builder, who pointed out some time ago that in reciprocating marine installations the highest attainable vacuum is not synonymous with overall economy, now gives expression to his opinion that the value of a vacuum of over twenty-eight and one-half inches for marine turbines is becoming, under many conditions, open to question. Almost everything in engineering is a compromise, and while on the one hand you may have a fair percentage of improvement in the steam consumption, on the other hand you have to consider the increased circulating-pump consumption, the increased weight and space for air and circulating pumps, the increased weight and space of the main condensers, the effect of reducing hotwell temperature, and the increased weight and space of the low-pressure turbines to satisfactorily utilize the high vacuum. It is possible, therefore, that we may come in the end to regard a practical limit in the reduction of back pressure as desirable, even for turbines.

READERS WITH SOMETHING TO SAY

Testing Springs for Pop Safety Valves

Recently I had to take out two locomotive pop-safety valve springs and replace them with lighter ones that were to carry only 30 lb. pressure. Not knowing the formula to find the right size of wire to make a spring capable of yielding at a given load, I used the testing arrangement shown. This outfit is home-made, consisting chiefly of fittings and a small tank found about the plant.

The procedure for testing these springs was as follows: I made a brass plug *A* to fit the safety valves which were also provided with $\frac{1}{4}$-in. nipples so that connection to an air hose could be made. The tank *C* was subject



Equipment for Testing Safety Valves

to air pressure at 100 lb. taken from the main air receiver. A gage was fitted to this tank so as to register the pressure within it. For testing the springs, air at 30 lb. pressure was admitted to and maintained in the tank, then, holding this pressure in the tank, the pop valves were set to operate at this pressure. This is perhaps one of the simplest ways to test springs and set such valves. The gage attached to the tank should, of course, be accurate.

James C. Mattison.

Vancouver, B. C.

First Aid in the Engine Room

There are steam plants in which not so much as a roll of cotton bandage can be found in case of injury to an employee. Every plant, no matter how small, should have something on hand for cuts, burns or more serious accidents. One can make a small cabinet in which such emergency supplies can be stored as peroxide of hydrogen, creoline, capsicol, unguentine, adhesive tape, one package of absorbent cotton and bandage tape; a pair of scissors and a Red Cross emergency instruction book.

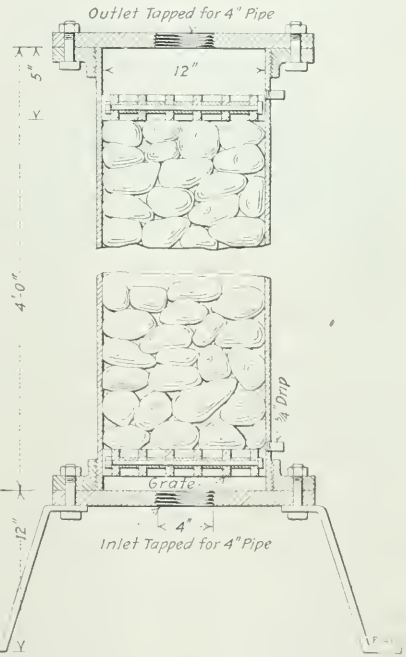
A first-aid kit for treating electric shocks and burns should contain one bottle of spirits of ammonia; one bottle of picric acid; a tin cup; a pair of tongue pliers; a towel; one package each of antiseptic cotton and antiseptic bandage; a roll of adhesive tape; a pair of scissors and an instruction book on the first aid in case of electric shocks and burns. A chart should be hung on the wall in full view of the employees, showing how to induce artificial respiration, and every man in the plant should be taught the procedure.

A. Lamarine.

New Bedford, Mass.

Compressed Air Dust Filter

After setting up an air compressor in the vicinity of an ore-reducing plant it was found that ore dust was drawn through the compressor, into the pipelines and finally into the pneumatic tools, causing trouble and expense.



Compressed-Air Dust Filter

After considerable experimenting with various types of screens the following was adopted: A piece of 12-in. pipe, about 1 ft. long, was fitted with cast-iron screwed flanges on both ends. A cast-iron plate, tapped for a 4-in. pipe was bolted to the lower end, also four wrought iron supporting legs.

A rough grate, made up of strips of $2 \times \frac{1}{4}$-in. flat iron with $\frac{3}{4}$-in. pipe separators $1\frac{1}{2}$ in. long, and held together with one $\frac{1}{2}$-in. bolt $11\frac{1}{4}$ in. long, was placed on the bottom. The pipe was filled to within 5 in. of the top with stones about the size of a large orange. The stones were dipped in a thick, sticky refuse oil, which

happened to be handy at the time, before they were placed in the pipe. As we figured that in time the oil would work to the bottom, a second grate, similar to the other, was placed on top of the stones so the apparatus could be turned over and used in a reversed position. A flange and gasket similar to that on the bottom was placed on the upper end. Drip cocks were also placed near each end so that any accumulated water might be removed. The line from the compressor was then connected to the bottom flange, by nipples, ells and flanged unions; the same arrangement was used on the upper end to convey the filtered air to the machines.

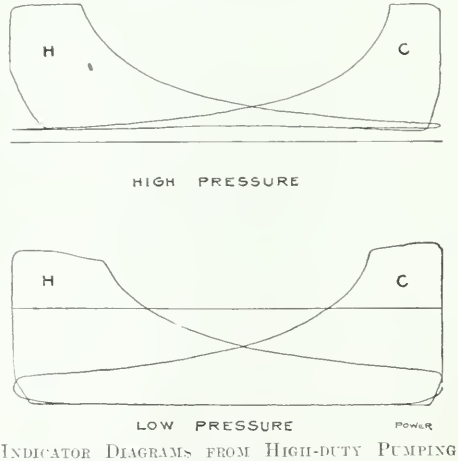
Since installing this device two years ago we have cleaned it twice, and on each occasion found that a large amount of dirt, lint, etc., had been collected by the oil, without any reduction in the efficiency of the oil. This same arrangement can be used on the discharge end of all lines if they are of any great length, as all wrought-iron pipe will shed loose scale, especially when first put in service, also after being out of use for some time.

W. G. Harris.

Elizabeth, N. J.

Indicator Diagrams from High Duty Pumping Engine

Yes, dear reader, you are right. The steam eccentric should be advanced a hair, the exhaust eccentric backed up three-eighths of an inch, the rod connecting the exhaust valves lengthened one full turn and the crank-end



Indicator Diagrams from High-duty Pumping Engine (High-pressure Crank Leads the Low by 90 Deg.)

governor rod lengthened one-sixteenth; but what causes the back pressure to increase slowly until midstroke and then slowly fall away until compression begins?

Don't spoil it all by asking if the cylinder is steam jacketed.

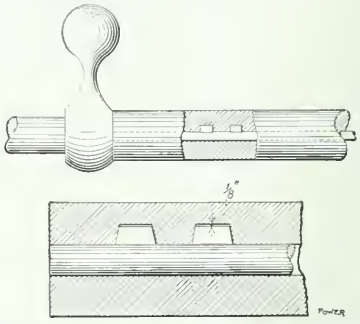
L. C. Tucker.

Newburyport, Mass.

[Our correspondent has anticipated the common criticisms and perhaps his own question. What would interest us more, is how he got that cutoff on the crank end of the high-pressure cylinder. Looks a little like a sticky indicator.—Editor.]

Reach Rod Lost Motion Eliminated

At the plant of which I have charge, trouble has been experienced in keeping the lost motion out of the engine reach rods. Shims were fitted each year when repairs were made, and, although the amount of wear would be small, it caused a disagreeable noise.



Reach Rod As It Was, also Showing Altered Shape of the Teeth

As the slots in the reach rods are made square, the teeth which fit in them are enough smaller to allow of easy connection. While making repairs last summer, I had the teeth and recesses made on a slight taper with the teeth large enough to bind on the sides before the bottom was within 1/8 in. from striking, as shown by the sketch. This makes it easy to hook up and has entirely and permanently removed the lost motion.

E. W. Meeker.

Cambridge, Mass.

Number of Boiler Passes

In an advertisement I noticed the claim that "the last pass of a boiler does not pull its own weight." I should like to ask the opinion of engineers on that subject. If this is true, why are some boilers being built now with four passes?

Furthermore, the statement does not coincide with the conclusion arrived at in the Bureau of Mines bulletin on the "Transmission of Heat into Steam Boilers," where the prediction is made that the boiler of the future will have more passes with proportionally smaller area of gas passages than at present on account of the increased economy to be realized. In this connection I should also like to state that I know personally where economizers were dropped from a proposed boiler house because the manufacturers were unwilling to guarantee that they would pull their weight.

Charles Cobb, Jr.

Kewanee, Ill.

[Mr. Cobb will be interested in the editorial entitled "Four Pass Boilers," in the Sept. 17 issue, and a letter discussing this editorial which appeared Feb. 25. We shall be glad to hear from any other readers having anything to offer on the subject.—Editor.]

Fireman "Lost His Head"

The following experience illustrates the necessity of "looking before you leap." Some years ago the writer was employed as a fireman in a plant having ten 250-hp. locomotive-type boilers, operating at 110 lb. pressure. Normally nine of the boilers were in operation and were handled by a force of three firemen, one of whom also attended to the needs of the feed pumps, which were in a room at the back of the boiler room.

One evening the chief fireman had gone to the pump room to attend to the lubricators, having first coaled his fires sufficiently to last the few minutes he expected to be away. On his return he heard the high- and low-water alarm sounding on No. 3 boiler, which was one of his set. Glancing up at the gage-glass and failing to see the water level, he immediately opened the blowoff valve a little and proceeded to coal up his fires, expecting the water soon to return to its normal level. When he finished coaling, the whistle was still sounding. The water could not yet be seen in the glass, so he then tried the gage-cocks which revealed that instead of being full of water the boiler was empty with a fierce fire in the furnace. First closing the blowoff valve, he speeded up the pump and, not content with this, he started the injectors.

About this time, while on duty at the further end of the room, I heard a violent pounding coming from the direction of No. 3 boiler. Running along the firing alley to investigate I noticed the empty gage-glass and divining the trouble, shouted to the chief to close the stop valve on top of the boiler, at the same time I closed the feed valve and, grabbing a shaking bar, dumped the fire into the ashpit.

By this time the pounding had ceased, but the whistles on all the other boilers were blowing, as a result of the increased speed of the pump and the extra water supplied to them by the injectors. An inspection of No. 3 boiler revealed a badly sprung firebox and showed that most of the tubes leaked at the ends.

Wheeling, W. Va. ROBERT TOMLINSON.

Overhauling Engine Pistons

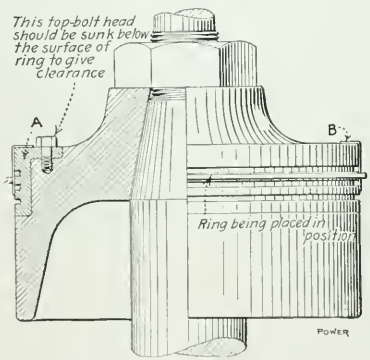
We all know of the losses incurred in steam-engine practice by leaky pistons, and, therefore, realize the necessity of frequently taking indicator diagrams to reveal these losses. It is probably good practice to overhaul the engine pistons every six months.

The designs of pistons vary from the simple solid block with grooves cut in its circumference to prevent leakage, to the types found in power stations and marine work, which have dozens of springs and segments all set together to form a continuous ring in contact with the cylinder wall. No matter what the design is, the function of the piston packing is the same in all cases, namely, to give a steam-tight working joint with a minimum of friction between the working parts.

With this end in view all springs in a spring-ring piston ought to be light, consistent with the working pressure, and with tension just sufficient to hold the surface of the ring in contact with that of the cylinder, against vibration and irregularity of the cylinder-wall surface.

One of the simplest and best pistons made, and one easy to overhaul, is shown herewith. The carrier *A* is of L-shaped section with three grooves sunk in its perimeter to hold in position three split cast-iron rings. To overhaul this type of piston, all that is necessary, once the cylinder head is removed, is to slacken back the tap bolts, which hold the carrier to the piston proper, then the carrier and rings can be lifted out and the rings examined for wear circumferentially and also as to width, for when there is too much clearance in the grooves, the rings chatter and are, therefore, more likely to become broken. If there is too much play, they should be replaced with rings of a breadth which is just a good fit, easily moved in the slot by hand. On no account should the rings be fitted tight, as they are likely to bind and be prevented from making contact with the cylinder wall.

In fitting rings circumferentially they must be fitted in the cylinder bore at its smallest diameter, after they have been split, and should be of a good fit, able to hold their own weight when in position, and about $\frac{1}{16}$ in. open at the joint where they are cut. If these conditions prevail the rings are ready to be sprung on the



PISTON WITH DETACHABLE PISTON-RING CARRIER

carrier. In doing this, care should be taken, as being of cast iron and very brittle, the rings are likely to be easily broken. Before the new rings are placed in position the carrier and grooves should be trimmed up with a smooth file and all sharp edges taken off.

The easiest and safest way of putting the rings in position is to take four pieces of sheet iron, $\frac{1}{16}$ in. thick by $\frac{1}{2}$ in. wide, and long enough to reach from the top edge of the carrier to the edge of the bottom groove, as shown at *B*. They should be bent L-shaped so that they cannot slip when a ring is being passed over them. These strips enable the rings to be slipped past the other grooves and placed where they belong.

Whatever attention is given to the piston is more than repaid in reduced steam consumption of the engine and smooth running of the plant. Therefore, a systematic overhauling of the piston is desirable in any plant.

Southampton, England. C. F. MACDONALD.

The 160-mile transmission line from the Ocoee River hydro-electric development of the Tennessee Power Co. to Nashville, connecting the system of the Nashville Ry. & Light Co., will be completed early in May. Only 20 miles more of wire remains to be strung. The work on the steel towers carrying the 66,000-volt lines is being pushed and it is expected the large force employed will be able to complete the work and enable the Nashville Co. to distribute hydro-electric power within 90 days.

QUESTIONS BEFORE THE HOUSE

The Average Owner

On page 980, Dec. 31 issue of POWER, is an editorial under this title: "The Average Owner," which, according to my experience, observation and analysis of conditions among such plants and their owners does not represent them as I have always understood them.

In dealing with the average plant we are confronted not only with dense ignorance, but also with an acrimonious passivity and psychic inertia that would stagger a government mule. I know the average plant and its atmospheric tension and morbidness. This is not said with the exclusion of the average plant owner, because you know that the atmosphere or spirit of any institution, no matter whether it is a power plant or a dry-goods store, is always dominated by its head, i.e., the personality of the man at the head, or leadership of the institution. The profound tact, knowledge and resourceful arguments of the uptodate engineer will be about as effective in such a plant as the idle winds. And if persisted in is likely to cause him to be looked upon as a nuisance or a cheap sort of side show.

But the well informed engineer is never found in such a plant, because there are no attractions there for him, and because he is not wanted is the reason for lack of attractions, and the reason he is not wanted is because the owner does not know what an engineer is.

When the owner becomes sufficiently awakened by the process of time and evolution and begins to realize that there are many things about the works that he does not quite understand, which are holding down the dividends, he begins to wonder if there is someone who does understand these things, and finds the engineer the person he needs. Under that condition the engineer gets a hearing when he wants something, but an engineer who is not president of the company, or an influential member of the board of directors of the average plant will not get on very fast, and moreover, will not stay there.

Then, too, a man who is studying for engineering soon develops ability that takes him away from the average plant, to one where he gets better remuneration, a better position and has a better prospect. Very meager wages are the rule among the average power plants. Also likewise very crude inefficient workmen are employed. The employers do not manage their business as they should, and the men they employ, and the wages they pay are a direct reflection of their judgment in general. Also the factory is not properly lighted and ventilated, the machinery not placed to the best advantage, which necessitates much extra handling of material and many other things come in here, all of which detract from the profits.

They have to pay for knowledge, before they will receive it. There is no use to try to give it to them, nor even to pound it into them, because they cannot see it, and, therefore, do not want it. Time and experience are the only agents that will change the average plant owner's notions of plant operation.

The letter on the lower right-hand corner, page 982 of POWER for Dec. 31 is typical of the average owner. I know the plants and country around Platteville, but never expected to see a letter from that neck of the woods published in POWER, and the author of the letter is more promising, energetic and ambitious than is the average individual of the neighborhood in plant life. He will see his mistake in a few months, and in that respect is much in advance of the average engineer or owner.

THOMAS C. ROBINSON.

Fort Madison, Iowa.

Cause of Knock in Gas Engine

In answer to Mr. Robnett's query in the Dec. 3 issue, page 837, as to the cause of the knock in his 60-hp. gas engine, I would advise that from the description he gives the knock is caused by a weak exhaust-valve spring. The fact that the engine runs quiet when up to speed is evidence that the trouble is not caused by any slack main journal or worn piston rings. If the exhaust-valve spring is weak enough to allow the valve to open on the suction stroke when the governor at full speed throttles the charge, there will be heard a click or knock when the valve seats itself at the end of the stroke. There may be a repeated sound as if the valve slapped against the seat two or more times. At a certain load this sound will be irregular, and will cease as the load is increased. For a four-cycle engine this knock will occur every second revolution.

The trouble being in one cylinder only would indicate either that one spring is weak, or, if there is one throttle valve for each cylinder, that the governor throttles more for one cylinder than for the other. The remedy in this case would be to adjust the governor connection so as to throttle equally in all cylinders. If the exhaust-valve spring actually is weak, a washer put under the valve-stem cap may increase the tension of the spring sufficiently to stop the noise. The force required in a spring to resist the partial vacuum formed in a throttling-engine cylinder at lightest load should be from 9 to 12 lb. per sq.in. of valve area.

Mr. Robnett states that the engine knocks while coming to speed. I presume this to mean the period before the load is thrown on, and if so, the throttling of the charge would have much influence on the action of the valve. If the statement refers to the short period (a matter of a few turns probably) while the engine is actually speeding up, there would then be no throttling; except by watching the governor it would be hard to tell exactly when throttling takes place.

A. M. LEONARD.

Chicago, Ill.

Mr. Robnett does not give complete details of his engine. Likely the throttling governor is at fault, either hunting or lagging, due to being too stiff or to the link-

being adjusted too tightly. If so, the engine would act as follows:

In increasing the speed of the engine, the governor would tend to lag and the engine would not get sufficient fuel on one stroke and the mixture would fail to ignite. On the next stroke, however, the governor having dropped, owing to the reduction in speed, would insure an increase in the quantity of fuel admitted to the manifold. There would be an explosion in the cylinder and the hot exhaust gases would ignite the weak mixture in the discharge pipe, causing a pronounced thump. This same action and explanation would account for the knock in one cylinder at every other revolution of the engine, if the gas leads to the various cylinders were so arranged that, while one cylinder got the full mixture, the other did not, and would also account for the knock disappearing at half load and loads above half load.

R. H. Danforth.

Annapolis, Md.

Solution of Reinforced Lap Joint Problem

In the Nov. 5 issue, J. H. Armstrong asks for the efficiency of a single-riveted lap joint which has been reinforced by a cover plate on the inside of the boiler.

At first, it looks simple to determine the efficiency of this joint. Referring to Fig. 1, we see that the joint will fail apparently by the shearing of the rivets *X* and *Y*, or by the tearing of the plate along the line of the *X* rivets (the line *EF* on Fig. 2). The plate cannot tear at any other place between *X* and *Y*, for, if it did, the rivets *X* would have to shear first to permit such action. If the joint has been well made and the rivets each take their share of the load, rivets *X* would not shear before rivets *Y*. Hence, the plate can tear only along the line *EF*.

If we draw the lines *AB* and *CD*, Fig. 2, we get a strip *ABCD* $1\frac{1}{8}$ in. wide, which we will call the unit strip. All our calculations are based on this piece, as the whole joint can be looked upon as a continuous line of these sections. The efficiency of the joint can be computed just as well from such a unit strip as from the whole length, with much more ease.

Referring to Fig. 2, we see that the strength of the unperforated strip will be equal to the product of the width of this strip, the thickness of the boiler plate and its tensile strength, or strength of the imperforated plate is

$$1\tfrac{1}{8} \times \tfrac{5}{16} \times 55{,}000 = 70{,}900 \text{ lb.}$$

The strength of the perforated plate in tension (along the line *EF*) equals the difference between the width of the strip and the diameter of the rivet hole multiplied by the product of the thickness of the plate and the tensile strength, or strength of the joint in tension is

$$(1\tfrac{1}{8} - \tfrac{3}{4}) \times (\tfrac{5}{16}) \times (55{,}000) = 58{,}000 \text{ lb.}$$

To find the strength of the joint in shear, we see that there are three rivets in single shear in the unit strip. The area of each rivet equals 0.442 sq.in. The force necessary to shear off one of them equals the product of the area of the rivet and the shearing strength of the rivet material, or the force to shear one rivet is

$$0.442 \times 42{,}000 = 18{,}560 \text{ lb.}$$

Hence, for the three rivets, the total force is three times as great, or 55,680 lb. So, the joint is weakest in shear and its efficiency will be the ratio of the weakest strength to the strength of the imperforated plate, or

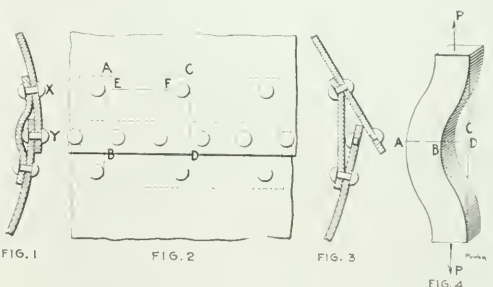
$$\textit{Efficiency} = \frac{55{,}680}{70{,}900} = 78.6 \textit{ per cent.}$$

as Mr. Armstrong calculated it.

The efficiency of the single-riveted lap joint without the cover plate can similarly be computed at 52.3 per cent., it also being weakest in shear.

Hence, we have, apparently, increased the efficiency by 40 per cent. of the original value by the addition of this cover plate. I doubt any such great increase, but would place the efficiency of the joint from 45 to 60 per cent. instead of 78.6 per cent.

The reasons for this statement are these: For the best results, the cover plate should be a snug fit against the inner heads of rivets *Y*. If it were not, the pressure on the cover plate would tend to straighten the latter, causing an extra strain on the *Y* rivets. This would be very large, as the cover plate would act like a toggle or knuckle joint. Only a very slight separation of the plate and rivet heads would be necessary to produce this effect, and it would be very hard to get a snug fit



Reinforced Boiler Lap Joint

along the whole length of the boiler seam. This action could be relieved partially by not calking the cover plate and allowing steam to get between this plate and the boiler plate. Otherwise, the cover plate, if it were not stiff, might be a source of weakness and the joint would be stronger without it.

But even with the cover plate snug against the rivet heads, the theoretical efficiency would not be realized. The rivets *X* and *Y* would not shear together, the rivets *Y* shearing first. The cover plate would probably bend straight between the rivet holes before the rivets *X* would give way (see Fig. 3). Of course, this would depend on the stiffness and thickness of this plate. Assuming its thickness to be equal to that of the boiler plate and, taking the approximate proportions as shown from Mr. Armstrong's drawing, I have calculated that the force acting along the circumference of the boiler plate would have to be about 1000 lb. per sq.in. to start straightening the plate. Hence, for the unit strip, the force would be

$$1000 \times 1\tfrac{1}{8} = 1120 \text{ lb.}$$

Using this value and considering that the rivets *Y* will shear before the others, I have calculated the efficiency of the joint to be about 60 per cent.

As for the force necessary to straighten the cover plate in this joint, I have calculated as follows:

Distance *AB* = thickness of the plate = $\frac{5}{16}$ in.

Distance BC = width, arbitrarily taken as 1 in.

Distance CD represents the offset to get around head of rivet = height of rivet head.

Height of head usually taken as 0.6 of rivet diameter = $\frac{15}{32}$ in. approximately in this case.

The question is what force P is necessary to start straightening the plate?

It is obvious that the plate will start to straighten when the greatest stress across the section ABC has passed the elastic limit stress for the material. This latter value may be assumed at about 32,000 lb. per sq.in. for low-carbon boiler plate. The greatest stress will occur along the inside of the bend, or along the line BC, and will be numerically equal to the sum of the stress due to the tensile load on the piece and the stress due to flexure or the fact that P is off center. This can be expressed:

$$\textit{Elastic limit stress} = \frac{P}{\textit{area } ABC} + \frac{\textit{bending moment on } ABC}{\frac{\textit{moment of inertia of section } ABC}{\frac{1}{2}\textit{ thickness of plate}}}$$

or,

$$32{,}000 = \frac{P}{\frac{5}{16} \times 1} + \frac{(P\,\frac{15}{32})}{\frac{\frac{1}{12}\,(1)\,(\frac{5}{16})^3}{\frac{5}{32}}}$$

solving, $P = 1000$ lb.

I agree with Mr. Armstrong that an applicant would be "up against it" with such a problem. The examiner must have put it in as a catch question or else through ignorance on his own part.

S. R. Wing.

Ithaca, N. Y.

Comment on Air Receiver Explosion

No matter what the occurrence may be, how seemingly impossible of explanation, or how vague the details, the word "mystery" has no place in the reports of boiler failures or compressed-air receiver explosions and its use in this connection, literally or by inference, should not be permitted to pass unquestioned.

Recently contributed reports of air-receiver explosions have been remarkably suggestive of "mystery," and they have also been noticeably deficient in presenting such facts and data as would permit the necessary calculation to ascertain the safe working strength of the receivers, if the reader so desired.

When one reads the account of an air-receiver explosion which states that "the receiver was being operated under normal conditions when suddenly the bottom of the receiver was observed to be red hot, closely followed by the explosion," and that "subsequent investigation showed that an accumulation of oil and grease on the interior surface had ignited, presumably from the heat of compression, the ensuing combustion so weakening the sheets that the failure resulted," the sensations produced, if he labors where a receiver operated under like conditions is installed, are much like those of the man who was told that the can he had been carelessly throwing around was full of nitroglycerin.

Occasionally, a report will include the data necessary for calculating the safe working strength of the exploded receiver and the reader is privileged to consider this factor and its possible bearing on the cause of the explosion. The report of the explosion of an air receiver at the McNamara silver mine, Tonopah, Nev., which appeared on page 810, in the Nov. 26 issue, which states that the "apparent" cause of the failure was the "ignition of oil and grease in the receiver," and which also contains the necessary data for calculation, is an instance where fact tends to controvert theory.

The shell of this receiver is described as 4 ft. in diameter and 16 ft. long, the longitudinal seam being a single-riveted lap-joint. The thickness of the plate is given as $\frac{3}{8}$ in. Assuming the tensile strength to be 45,000 lb. per sq.in., and the per cent. of strength of the longitudinal joint as 0.56, the bursting pressure of the receiver is computed from the formula:

$$\frac{\textit{Tensile strength} \times \textit{thickness of plate} \times \textit{efficiency of joint}}{\textit{radius in inches}}$$

Substituting values,

$$\frac{45{,}000 \times 0.375 \times 0.56}{24} = 393.7 \textit{ lb. per sq.in.}$$

As 5 is the usual factor of safety for this type of construction, the safe working pressure will be $\frac{1}{5}$ the bursting pressure, or

$$393.7 \div 5 = 78.74 \textit{ lb. per sq.in.}$$

The pressure carried was stated in the report to be 100 lb. (gage). As this is nearly 25 per cent. greater than the commonly accepted rules of safety would sanction, and as it is reasonable to suppose that the receiver had become more or less weakened from corrosion during its seven and one-half years of service, there seems to be good grounds for doubting the "oil ignition" theory in this instance at least.

It must be admitted that the elements which enter into the compression of air are such as to be capable, under certain conditions, of being ignited and exploding, but I am very skeptical that the required conditions are ever present in the ordinary process of compressing. For twenty years I have observed air compressors and receivers subjected to abuse, if introducing unfit lubricants into the compressor and receiver can rightly be termed abuse. In locomotive practice I have seen enginemen admit quantities of kerosene, lard oil, tallow, car oil, engine oil and cylinder oil through the suction inlet of the air pump in their efforts to stop the annoying "groaning" of the pump, and, although the drainage of these receivers almost without exception shows the presence of oil, I fail to recall an instance of receiver failure.

Like the "hidden lap-seam crack" in boiler explosions, this "oil-ignition" theory makes a good "cover" for the concealment of gross carelessness in operating equipment which was unsuited for the purpose for which it was used, and unless more conclusive evidence than has yet been presented is forthcoming it is likely to be so regarded.

Lynn, Mass. Joseph King.

As a result of a dinner given by the Minneapolis General Electric Co., the Minneapolis Electrical Board, consisting of seven members, has been formed. Each member represents one of the following electrical interests: Wholesale houses, retail dealers, sign manufacturers, contractors, fixture dealers, city inspection department, and the central station. The board will meet once each month for the discussion of things of mutual interest, and every effort exerted toward the greater electrical development of Minneapolis.

INQUIRIES OF GENERAL INTEREST

Gravity—What is meant by the force of gravity?

K. V. S.

All matter on or near the earth is attracted toward the center of the earth by a force known as gravity. The weight of any given body is the effect of this attraction.

Nonfreezing Mixture for Gage Pipe—Where a steam gage must be exposed to a low temperature, what is a suitable mixture with which to fill the gage and pipe leading to it so that it will not freeze?

J. C.

Numerous nonfreezing mixtures are suitable, but a cheap and effective fluid is plain kerosene oil.

Pipe-Covering Tests—Where may one obtain reports or data of tests on the efficiency of pipe covering and the heat loss to the atmosphere per unit of exposed surface?

J. G. B.

A compilation of tests on the heat lost through various pipe coverings is given in Paulding's "Condensation of Steam in Covered and Bare Pipes." The table is reprinted in the Stirling Boiler company's catalog, page 219.

Kerosene a Distillate—How much solid matter is there in a barrel of kerosene, i.e., how much residue would remain after evaporating 50 gal. of the oil?

J. H. T.

There should be no solid matter in kerosene unless it got into the oil subsequent to the manufacture, for kerosene is obtained by distilling heavier oils and, being a product of recondensation, will vaporize entirely if pure.

Motor-Generator Efficiency—What is the usual efficiency of a motor-generator set?

C. Y. L.

The efficiency of a motor-generator set depends upon its size. If both sides are direct-current, it will vary from about 72 per cent. for one of 5 hp. to about 82 per cent. for one of 100 hp. If either or both sides are alternating current, the efficiency will be further reduced by the power factor.

Variation of Atmospheric Pressure with Altitude—Why does the atmospheric pressure decrease as the altitude increases?

V. K. S.

The pressure of the atmosphere at any point is due to the weight of air above that point. At any greater elevation the amount and hence the weight of air still above being less, the pressure will also be less.

Restoring Polished Surfaces—How can the polished surfaces of an engine be made bright again after becoming coated with burned or baked oil and dirt?

J. F. C.

The discoloration generally is not very deep and then can be removed with emery cloth. If oil and dirt have become baked on as a thick coating, oxalic acid will soften it, but the bright surfaces can be restored only by scraping and polishing with emery cloth.

Specific Gravity of a Body—What is the specific gravity of a body and how is it found?

S. K. V.

The specific gravity of a body is its weight for a given volume as compared with the weight of an equal volume of water. To find the latter, weigh the body in the air and then immersed in water. The difference between the two weights will be the weight of water displaced or the weight of the equal volume of water. Dividing the weight of the body in the air by the weight of the displaced water gives its specific gravity.

Pressure of Water Head—If a gage is attached at the foot of a 1-in. vertical pipe filled with water to a height of 34 ft., what should it register?

J. M. H.

The size of the pipe has no bearing in the matter, for the pressure due to a column of water is independent of the area of its cross-section, depending only on its height, and the density of the water, which varies with its composition and temperature. If the surface of the water stands 34 ft. above the center of the gage, the water is fresh and the temperature is about 62 deg. F., each foot of height will create a pressure of 0.433 lb. per sq.in., and a correct gage should indicate

$$34 \times 0.433 = 14.722 \text{ lb. per sq.in.}$$

Polarity of a Dynamo—How can one determine which are the north and which the south poles of a dynamo?

G. K.

This cannot be determined by mere inspection unless it is known in which direction the current flows around each pole. This being known, the north pole will be found at the end toward which the core would travel if it were a right-hand screw and were revolved in the direction that the current travels. The polarity can be determined by a test with a permanent bar magnet or with a magnetic compass. If the north end of such a magnet is attracted when brought toward a pole face it indicates that that face is a south pole; if repelled, that it is a north pole. The magnet, especially if a compass, must not be brought so close that the greater force of the machine pole may reverse its magnetism, for then it would be attracted regardless of its original magnetic condition.

Exhaust-Steam Injector—How can exhaust steam from a noncondensing engine force water against boiler pressure as is done in the exhaust-steam injector?

H. H. J.

It is not by the direct pressure of the steam that any injector forces water into a boiler. In the injector the steam is condensed and, its volume being greatly reduced, its pressure would be also, no matter how high it had been originally. The principle is different; the steam passing through an expanding nozzle has its energy converted into velocity, and, being injected into the core of a contracting column of water, is condensed, and water closes in behind to fill the vacuum. Meantime velocity has been imparted to the combined column of water and condensed steam and, proceeding through the expanding delivery tube, the velocity is largely converted back to pressure.

In a sense an injector may be compared to a lever or any force-multiplying mechanism. Where the pressure of the steam is low (as in an exhaust steam injector) it simply means that more steam must be used relative to the quantity of water delivered against the given pressure. The analogy with a lever is that where the working force is small the lever must be longer to lift a given weight.

Saving by Covering Boiler—A boiler has 2000 sq.ft. of surface exposed to the atmosphere in a boiler room whose average temperature is 100 deg. F. The steam pressure is 110 lb. gage. Crude oil is burned of a calorific value of 18,700 B.t.u. per lb., costing $1.20 a barrel of 315 lb. In an operating period of 4000 hr., what would be the saving by putting on the exposed boiler surface a covering of 85 per cent. efficiency?

B. G. J.

The temperature of steam at 110 lb. gage is 344.2 deg. F. The difference of temperature between the steam and the boiler room is, therefore,

$$344.2 - 100 = 244.2 \text{ deg. F.}$$

At the usual assumption of 3 B.t.u. radiated per hour per square foot per degree difference of temperature, the total loss in 4000 hr. is

$$3 \times 4000 \times 2000 \times 244.2 = 5{,}860{,}800{,}000 \text{ B.t.u.}$$

The calorific value of the oil being 18,700 B.t.u. per lb., and the evaporating efficiency of the boiler probably 75 per cent., the heat put into the steam by each pound of oil is about

$$18{,}700 \times 0.75 = 14{,}025 \text{ B.t.u.}$$

and by each barrel,

$$14{,}025 \times 315 = 4{,}417{,}875 \text{ B.t.u.}$$

To cover the loss then will require

$$\frac{5{,}860{,}800{,}000}{4{,}417{,}875} = 1327 \text{ bbl. of oil,}$$

costing

$$1327 \times 1.20 = \$1592.40.$$

Covering of 85 per cent. efficiency would, therefore, save

$$\$1592.40 \times 0.85 = \$1353.51.$$

ENGINEERS' STUDY COURSE

Mensuration—Part V

Pyramid, Cone and Frustum

A *pyramid*, Fig. 1, is a solid, the base of which is a polygon, and the sides triangles. The point where the lines forming the sides meet is called the *apex* or *vertex* of the pyramid.

The perpendicular distance between the apex and the base, as indicated by the dotted line, Fig. 1, is termed the *altitude* of the pyramid.

The *slant height* of a side of a pyramid is the altitude of the triangle forming that side.

The *lateral edges* of a pyramid are the lines from the apex to the corners of the base.

Fig. 1

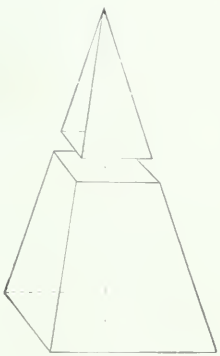


Fig. 2

If we cut off the top of a pyramid, as in Fig. 2, the lower or remaining part will be a frustum.*

Cones

A circular cone is a solid whose base is a circle and whose sides taper uniformly to a point called the apex or vertex. Fig. 3 shows a circular cone. The altitude of a cone is the perpendicular distance between the apex and the base, as shown by the dotted line, Fig. 3.

The *slant height* of a cone is the distance between the apex and a point on the circumference of the base.

A frustum of a cone is formed in the same way as the frustum of a pyramid, as shown in Fig. 4.

The altitude of a frustum of a pyramid or cone is the perpendicular distance between the upper and lower bases, as shown in Figs. 2 and 4.

The slant height of a frustum is the perpendicular distance between the corresponding edges of the upper and lower bases.

Areas

You have undoubtedly noticed that the sides of a pyramid are made up of triangles of which the altitudes are equal to the slant height of the pyramid, and whose bases are equal to the edges of the base of the pyramid, which if a regular polygon will produce equal bases for all the triangular sides. We may also consider a cone as a pyramid of which the base is a regular polygon with a great number of sides, for we know that if we make a polygon with a sufficient number of sides we will produce a nearly perfect circle.

We may now make the following rules for the areas of the pyramid and cone and their frustums:

Rule: *To find the lateral area of a pyramid or cone, multiply the perimeter of the base by one-half the slant height.*

The overall or total area equals the lateral area plus the area of the base.

Rule: *To find the lateral area of a frustum of a pyramid or cone, multiply one-half the sum of the perimeters of the upper and lower bases by the slant height.*

Example: The roof of a tower shaped like a pyramid and of the following dimensions, one side of the base 42 ft., and the slant height 62 ft., is to be covered with sheet copper. Allowing 60 sq.ft. extra for the seams and waste, how many square feet of copper will be required?

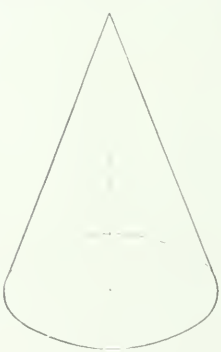


Fig. 3

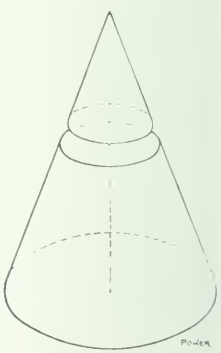


Fig. 4

The perimeter of the base will be

$$42 \times 4 = 168 \; ft.$$

and the lateral area will be

$$168 \times \tfrac{62}{2} = 5208 \; sq.ft.$$

The copper necessary will be

$$5208 + 60 = 5268 \; sq.ft. \quad \text{Ans.}$$

Example: How many square feet of copper would have been necessary if the tower in the above example had been shaped as a cone of which the base was of the same diameter and the slant height was the same.

The perimeter or circumference of the base would be

$$3.1416 \times 42 = 131.94 \; ft.$$

and the lateral area would be

$$131.94 \times \tfrac{62}{2} = 4090.14 \; sq.ft.$$

* Some authorities say that the upper and lower bases need not be parallel, but for the purposes of this course it is preferred to consider that one of the conditions of a frustum.

Allowing 60 sq.ft. for the seams and for waste, the amount of copper necessary will be

$$4090.14 + 60 = 4150.14 \text{ sq.ft.} \quad \text{Ans.}$$

The 12x12x24-in. prism, Fig. 5, has six sides, and examination of it will show that it contains six pyramids, the four sides of the prism forming the bases of four pyramids, and the two ends of the prism making the bases of the other two pyramids. For convenience the bases of four pyramids only have been numbered, 1, 2, 3 and 4.

This prism has a certain volume and as it contains six pyramids their total volume will equal the volume of the prism.

The rule for finding the volume of a pyramid or cone is:

Rule: *The volume of a right pyramid or cone equals*

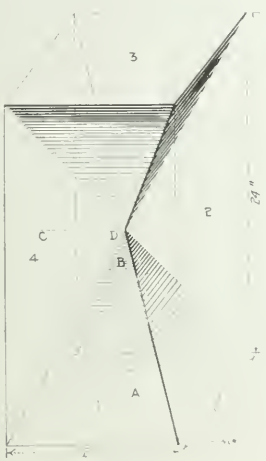


FIG. 5

the area of the base multiplied by one-third the height or altitude.

Then the volume of either the upper (inverted) or lower pyramid in Fig. 5 will be

$$12^2 \times \tfrac{1}{3} \times 6 = 576 \text{ cu.in.}$$

Let us apply the rule to one of the pyramids with the large or 24x12-in. bases. The altitude CD is one-half the width of the prism, or 6 in., so the volume will be

$$24 \times 12 \times \tfrac{6}{3} = 576 \text{ cu.in.}$$

We see that the volume of each pyramid in the prism is equal to one-sixth of the volume of the prism and so must equal the area of the base times one-third the altitude BA for the end pyramids and one-third of CD for a pyramid the base of which is the side of the prism.

The volume of a cone is also equal to one-third the volume of a cylinder with a like base and altitude, just as the volume of a pyramid is one-third the volume of a prism of an equal base and altitude. This explains the rule for the volume of a pyramid or cone.

When coal, crushed stone, sand and other fine material is dumped on the ground or surface through an opening considerably above the surface, the pile will assume the form of a cone.

Example: A long ton (2240 lb.) of hard coal occupies 36.7 cu.ft. How many tons in a conical pile 30 ft. in diameter with an altitude of 43 ft.?

The volume of the pile is

$$30^2 \times 0.7854 \times \tfrac{43}{3} = 10,131.66 \text{ cu.ft.}$$

So its weight in tons must be

$$10,131.66 \div 36.7 = 276.07 \text{ tons}$$

To find the volume of a frustum of a pyramid or cone:

Rule: *Add together the areas of both bases, the square root of the product of both bases and multiply the sum by one-third of the altitude.*

This rule is more conveniently expressed as a formula.

$$V = \tfrac{1}{3} h (B + b + \sqrt{B \times b})$$

in which

V = Volume;
h = Height or altitude;
B = Area of lower base;
b = Area of upper base.

Example: Medium-hard brickwork will weigh 125 lb. per cu.ft. What will be the weight of a brick engine foundation shaped as a frustum of a pyramid, the lower base of which is 12x8 ft.; upper base, 10x6 ft. and having an altitude of 9 ft.?

Substituting these values in the formula we have

$$V = \tfrac{9}{3} (12 \times 8 + 10 \times 6 + \sqrt{12 \times 8 \times 10 \times 6})$$

or

$$V = 3 \times (96 + 60 + \sqrt{96 \times 60}) = 695.67 \text{ cu.ft.}$$

The weight will be

$$695.67 \times 125 = 86,958.75 \text{ lb.}$$

Example: A reservoir shaped like the frustum of a cone has an upper base 300 ft. in diameter and a lower base 260 ft. in diameter; the depth of water when full to overflowing is 21 ft. How many gallons of water could the reservoir contain?

The volume of the reservoir is

$$\tfrac{21}{3} \times [(300^2 \times 0.7854) + (260^2 \times 0.7854) + \sqrt{(300^2 \times 0.7854) \times (260^2 \times 0.7854)}]$$

or

$$7 \times (70,686 + 53,093.04 + \sqrt{70,686 \times 53,093.04}) = 1,295,281.68 \text{ cu.ft.}$$

The capacity in gallons will be

$$\frac{1,295,281.68 \times 1728}{231} = 9,689,379.81 \text{ gal.}$$

EXAMPLES FOR PRACTICE

(1) Cast iron weighs 0.26 lb. per cu.in. What will be the weight of a pyramidal casting (iron) whose base is 2x2 ft. and whose altitude is 18 in.?

(2) (a) A roof tank on a sprinkler system is shaped like a frustum of a cone. The lower base is 6 ft. in diameter, upper base 4 ft. 6 in. in diameter and the altitude is 8 ft.; what is its capacity in gallons?

(b) If the tank weighs 1057 lb. when empty and the allowable weight on the roof is 550 lb. per sq.ft., what will be the length of a side of the square formed by the supports of the tank?

(3) If a wagon has a capacity of 5 cu.yd. of ashes, how many wagon loads will be contained in a hopper which consists of a room 10x10 ft. wide, 10 ft. high; the floor of the room is shaped like an inverted pyramid whose altitude is 6 ft. from the lowest level of the side walls?

(4) How many linear feet of 12-in. boards are required to build a housing for a tank: the housing is to be shaped like a frustum of a pyramid whose lower base is 12 ft. square, upper base 10 ft. square and whose altitude is 11 ft.

ANSWERS TO LAST WEEK'S PROBLEMS

(1) 57.6 seconds.
(2) 61,949 sq.in.
(3) 2705.29 lb.

⁂

New Blades for "Lusitania's" Turbines

The Cunard liner "Lusitania" is now at Clydebank undergoing extensive repairs to her turbines. As the blades of all her turbines, with the exception of the high-pressure port machines, are to be renewed, the Cunard authorities state that the liner will not go into service for many months.

As previously stated in POWER, the "Lusitania" has been most unfortunate with her turbines ever since her initial voyage in September, 1907. For the first few years serious trouble occurred at rather long intervals, but more recently the turbines began to show, by serious breakdowns about every three months, the effect of inadequate care, which is perhaps entirely due to the exigencies of the service and not to incompetent handling or poor design.

Some marine engineers claim that much of the "Lusitania's" turbine trouble is due to the serious foaming and priming of her triple-furnace Scotch boilers, which allow such quantities of water to get into the turbines as to seriously erode the blades, many of which have been renewed at frequent intervals lately.

According to a report in the *New York Times*, Feb. 25, which the New York office of the Cunard company will not confirm, a commission of engineers recommended that the liner be put in drydock and the blading of all her turbines, except the high-pressure port machine, be renewed, the new blades to be cast in sections and riveted to the shaft instead of fastening them singly as has been the practice. This plan was adopted because it has proved so satisfactory with the "Mauretania's" turbines. The estimated cost of the repairs is $500,000.

⁂

Electrical-engineering students in the technical schools of this country in 1912 numbered 8921, according to a compilation of statistics in the "Electrical World," Nov. 23, 1912. In that year 1496 graduated, bringing the total number of graduates during the past six years up to 18,318. The statistics for the six years past are shown below.

	1907	1908	1909	1910	1911	1912
Number of students	8929	9651	8670	8041	9515	8921
Number of graduates	1358	1501	1473	1545	1614	1496

⁂

It took a pull of 364 tons to break the largest hoisting cable in the world, when sections were tested early in December in the 800,000 lb. testing machine of the Fritz Engineering Laboratory at Lehigh University, South Bethlehem, Penn. Three tests were made, all highly satisfactory. A piece of the cable that had been in use for a year and a half withstood a pull of nearly 300 tons. The construction of this cable is said to be without precedent in rope-making. It consists of six strands, each of nineteen wires, twisted around an independent wire rope center, this center having six strands of nineteen wires each, twisted around a hemp core. The finished cable is 7810 ft. long, and weighs 125,360 lb. Cars with a capacity of 100,000 lb. of ore are lowered by means of this cable down an inclined plane 5800 ft. long.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The first issue of Brother Mackintosh's handsome publication, "Steam Machinery," comes with a creed of "Labor with Laughter." Mac says "the times are ripe for a frivolous magazine with serious purpose"—and he only wants "one perfectly good ingodwetrust dollar for a full year's treatment." Go to it, brother! Your first essay already proves you deserve the golden wrest from the guild of ye joyous troubadours; you're some hummer!

⁂

Somebody says that all the professions have benefited by mechanical invention save the lawyers. They have only the friction brake, and successfully apply it to the wheels of justice. Officer, eject Somebody from the courtroom, put a detective on Friction's trail, and call the next case.

⁂

A Newport News boilermaker, "near death with appendicitis," hot-footed it for home when it came time for the hospital surgeon to "start up." The ill doctor makes the most scared patient. Here's a man who can cut out a boiler, but when the surgical "boilermaker" shows up with his little tube-scraper—awk, it can't be done!

⁂

In Bulgarian currency, 100 stotinks equals 1 lev, or 19.3 cents. Just think of having to save up a hundred stotinks before you can accumulate a lev, or of putting a stotink on the plate Sunday morning. Now, Bulgaria intends to mint other coins. Bet you 2 kopecks against 1¼ yards of Chinese coin that you can't name the new issues.

⁂

A mining engineer is sometimes hard put to keep cheerful under adverse conditions. One in the Golden West says he is working on the "graveyard" shift at the Dead Man mine, in the Funeral Mountains, near Death Valley. Some "embalming fluid," about 98 per cent. proof, might help, but two weeks on this job would make an ordinary man look like a professional pallbearer, and Chopin's "Funeral March" would sound like a ragtime ditty.

⁂

Postals naming ten famous engineers have been received from W. C. Collins, Everett, Mass., and O. L. Sherman, Duluth, Minn. Their lists accord well with that of Prof. Kent in the Mar. 4 issue.

⁂

THANKS! SAID HE

By Billy Spills

Once upon a Time there was a Molder of Public Opinion (M O P O = Editor, sometimes) whose hard Lot it was to fill the boots of old Doc. Knowitall—he had to answer the "Inquiries."

F'rinstance, when Subscriber got keen for a new License, he would corral a copy of 69 old Questions and Demand real sassy that Doc. answer them Immediate, or he'd stop Subscribing; he wouldn't even Borrow his fireman's paper. In a Manner of speaking, Doc's inquisitors Hogtied him to the Rack, and then racked him for the whole Hog.

The Pace began to tell, and Doc. looked Off his feed, bilious-like, and depressed.

One day it appeared as if the crisis had Came when Doc. ambled over to Us, determined-like. "Say, Spills," says He, "even s'posin' an editor does get Seven thousand dollars a year"—which is a Wild supposition—"the Grind thumps your nerves awful Fierce. I ain't gettin' anything but Money for all this dinged worry. If Somethin' don't happen before the End of the week, I'm agoin' to Chuck up. Do you get me, Billy?"

Something Did happen, and You wouldn't know Doc. today. He got these Few cheering lines in his Monday mail:

"I thank you for your prompt and helpful reply to my recent inquiry. * * * I am much gratified at your very satisfactory answer to my cry for help.

"GRATEFUL SUBSCRIBER."

There's nothing really True in this story except Grateful Subscriber's letter, unless you want to include Doc's Surprise.

Accuracy and Limitations of Coal Analysis

SYNOPSIS—Accuracy depends largely on the kinds of coal, methods employed and the skill of the analyst. Some interesting data to show the limits of accuracy in sampling, in obtaining proximate and ultimate analyses and heat value of coal by calorimeter or computation.

In coal analysis, discrepancies, which are more likely to occur in some determinations like that of volatile matter or of fixed carbon, tend to discredit the whole analysis in the eyes of engineers not familiar with the difficulties peculiar to such individual determination. A. C. Fieldner, of the Bureau of Mines, in a paper read before the American Coal Mining Institute, called attention to this fact. He pointed out that some constituents may be determined much more accurately than others, and presented experimental data bearing on the probable variations that may occur in good laboratory practice. In the following, only a summary of these data will be given.

Moisture

In the Bureau of Mines method, the moisture is determined in two stages: (1) the coarse sample received by the laboratory is pulverized to ¼ in. size and then air-dried at 86 to 95 deg. F. The loss in weight, which is called the air-drying loss, includes all the superficial moisture and a large portion of the loosely retained moisture. (2) The air-dried sample is then pulverized in a closed ball mill to avoid loss of moisture, mixed and sampled down to a small, powdered sample in which the residual moisture is determined, by heating one gram for one hour at 221 deg. F., in an oven through which dry air is being circulated. By this method duplicate results in the same powdered sample seldom vary more than 0.15 per cent.

Ash

The determination of ash, although one of the simplest operations, is also beset with certain difficulties that lead to disagreement among different laboratories, more especially with coals containing notable quantities of calcium carbonate and iron pyrites. For example, in certain experiments with Illinois coal that contained notable quantities of calcium carbonate and sulphur, 11 per cent. ash was obtained by ignition to constant weight at a low-red heat, and 13 per cent. ash was obtained by ignition at a bright-red heat. To secure concordant results, a standard temperature should be adopted. If this is done, duplicate determinations on the same powdered sample will agree to within 0.2 per cent.

Coal ash as determined usually weighs less than the mineral matter from which it is produced. Several methods have been proposed to compute the weight of original mineral matter in the coal, by adding corrections to the weight of ash obtained by ignition. These methods are, however, too complicated and uncertain in their general application to all classes of coal to be used in technical work.

Volatile Matter and Fixed Carbon

The volatile matter and fixed carbon represent the relative proportions of gaseous and solid combustible matter that may be obtained from the coal by heating it in a closed vessel. This is done by heating a finely powdered sample in a small, covered platinum crucible, in the flame of a Bunsen or Meker burner for exactly seven minutes. The volatile matter consists mainly of the combustible gases—hydrogen, carbon monoxide, methane and other hydrocarbons—and some noncombustible gases, as carbon dioxide and water vapor. The volatile matter does not include water present in the coal as moisture at 221 deg. F.

The residue of coke left in the crucible after deducting the ash is reported as "fixed carbon." The fixed carbon does not represent the total carbon in the coal, as a portion of this element is driven out in combination with hydrogen in the volatile matter; furthermore, fixed carbon is not pure carbon, but still contains several tenths per cent. each of carbon, hydrogen and oxygen; from 0.4 to 1 per cent. nitrogen; and about half the sulphur that was in the coal. It should be clearly understood that the terms "volatile matter" or "volatile combustible matter" and "fixed carbon" do not represent any definite compounds which existed in the coal before heating. The method of determination is purely arbitrary, and variations in temperature and rate of heating will cause variations amounting to several per cent. Even with a strict adherence to the method recommended by the American Chemical Society, variations of 3 and 4 per cent., in both the volatile matter and fixed carbon, may occur in different laboratories. One of the most prominent factors in causing variations is the temperature at which the crucible is heated. This is especially pronounced in anthracite and semibituminous coal. It is easily possible for one laboratory to report 4 per cent. and another 7 per cent. volatile matter on the same sample of anthracite, or 14 per cent. and 17 per cent., respectively, on the same sample of Pocahontas coal. The different percentages of volatile matter were actually produced by different conditions of heat treatment. Caution must, therefore, be observed in making comparisons of the volatile matter and fixed carbon in proximate analyses made in different laboratories. Even determinations made at the same laboratory by the same analyst may vary to the extent of 0.5 per cent.

Sulphur

Sulphur determinations by the "Eschа" method on the same powdered sample will usually agree to within 0.05 per cent. Where much sulphur is present in visible form, as pyrite, difficulty is experienced in obtaining a representative powdered sample from the coarse sample, and somewhat greater errors due to inaccuracy in sampling may occur.

Ultimate Analysis

In an ultimate analysis, the organic matter of the coal is resolved into the chemical elements, viz.: carbon, hydrogen, oxygen and nitrogen. These elements, together with the ash, are taken as equal to 100 per cent. As there is no direct method for the determination of oxygen, it is estimated by subtracting the sum of the other five constituents from 100. This method throws the summation of all the errors incurred in the other determinations upon the oxygen.

The determination of carbon, hydrogen and nitrogen, while requiring experience and a considerable degree of analytical skill on the part of the chemist, is not subject to the arbitrary conditions that must be maintained in the proximate analysis. As the chemist is dealing with definite chemical elements, he should be able to duplicate his determinations within the following limits: Carbon 0.3 per cent., hydrogen 0.05 per cent., nitrogen 0.03 per cent.

In the present method of estimation, the oxygen percentage is subject to an error equal to the algebraic sum of the individual errors incurred in the determination of carbon, hydrogen, nitrogen, sulphur and ash. The most serious of these errors is due to the difference in weight between the ash and the mineral matter (exclusive of sulphur which is separately determined) as it occurs in the coal.

Calorific Value

The term "available hydrogen" often used in the computation of the calorific value of a coal from the ultimate analysis, is based on the assumption that all the oxygen in the coal is combined with hydrogen in the proper ratio to form water. The amount of hydrogen thus combined and not available for producing heat is equal to one-eighth of the oxygen; the remainder of the hydrogen, or "available hydrogen," is combined with the carbon and contributes to the heat value of the coal. This hypothesis is largely well supported in the case of anthracite and bituminous coal by the general agreement of calorific values calculated from the ultimate analysis by Dulong's formula with the values determined by the bomb calorimeter.

The most accurate method of determining the total heat value is by combustion in a bomb calorimeter. The instrument should be carefully standardized by burning substances of known calorific value, such as the standard samples of cane sugar, naphthalene and benzoic acid that are now being furnished by the Bureau of Standards. The standardization should be conducted under exactly the same conditions, and with the same thermometer, that is used in the tests. The use of calibrating thermometers is essential. In carefully conducted calorimetric tests, the probable error should not exceed 0.5 per cent., which corresponds to about 50 B.t.u. in the high-grade coals. This is a higher degree of accuracy than can be obtained in the usual methods of sampling, which oftentimes increase the error to 100 B.t.u.

Calculation of Calorific Value by Dulong's Formula

Before the bomb calorimeter came into general use, the heat value of a coal was frequently calculated from the ultimate analysis by Dulong's formula:

$$\text{Calorific value in B.t.u. per lb.} = 14{,}544\ C + 62{,}028\ (H - \tfrac{1}{8}O) + 4050\ S$$

In the above formula, C, H, O and S are the respective proportions of carbon, hydrogen, oxygen and sulphur.

Aside from the fact that an ultimate analysis is more expensive and time consuming than a calorimetric determination, there are the following theoretical objections to be considered:

1. The heat value of the elements—carbon, hydrogen and sulphur, as given in the formula—has not been established with any great degree of accuracy.

2. The heat value of an element in the free state and as a component of a chemical compound is not necessarily the same, as a matter of fact, it usually varies, due to absorption or evolution of heat in forming the compound.

3. The usual assumption that from the standpoint of heat development all the oxygen is combined with hydrogen, may not be true; some of the oxygen may be linked with carbon.

4. The relative accuracy of the calculated results is subject to the uncertainty of the oxygen estimation.

On the other hand, in spite of the objections just cited, there is fairly close agreement between the calorific values calculated by Dulong's formula and those determined by the calorimeter. Lord and Somermeier, in an extended series of analyses of the coals of Ohio, found that, with very few exceptions, the results obtained by Dulong's formula were within 1 to 1½ per cent. of the values obtained with the bomb calorimeter. This degree of accuracy has also been found to hold true with anthracite, semibituminous and bituminous coals from various parts of the United States.

A total of 176 analyses was selected at random from the records of the chemical laboratory so as to secure about 20 to 30 samples of each representative class of coal from the most recent lignites, through the range of subbituminous, bituminous, semibituminous and anthracite coals of Pennsylvania. For comparison a number of peats were also included in an extended table presented with the paper.

The tabulation brings out in a striking manner the variation in the relation between the heat value calculated by Dulong's formula and the true heat value as determined in the bomb calorimeter. This relation is within certain limits, characteristic of the class of coal. For instance, in coals low in volatile matter and oxygen, like anthracite and Pocahontas coal, the calculated value is usually from 0.3 to 1.5 per cent. greater than the determined value. In only very few instances is the calculated less than the determined value; in the bituminous coals, the calculated values vary both above and below the determined values usually within limits of 1.5 per cent.; in subbituminous and lignite coals the calculated value becomes less than the determined value as the oxygen increases; the deviation often reaching 4 and 5 per cent.; in peat the calculated results are quite unreliable, the results being from 3 to 11 per cent. low.

Calculation of Calorific Value from the Proximate Analysis

The calculation of calorific values by formulas depending on the proximate analysis is apt to give quite erroneous results. Such methods are subject to the considerable uncertainty of the fixed carbon and volatile matter determinations. Furthermore, the variable proportion of inert volatile matter, which does not contribute to the heat value, is not taken into consideration.

A fairly accurate method of calculating the heat value of Appalachian, bituminous and semibituminous coal from the same mine and seam, is based on the constancy in heat value of the "combustible" or coal substance free of moisture and ash. The calorific value of a coal may be referred to a moisture-free basis by dividing the

calorific value as determined by one minus the sum of the moisture and ash in the unit weight of fuel.

$$\textit{Moisture-and-ash-free calorific value} = \frac{\textit{Calorific value as determined}}{\frac{1-(\textit{percent. moisture}+\textit{percent. ash})}{100}}$$

Some moisture-and-ash-free calorific values of mine samples taken by engineers of the bureau at different points in a number of mines in Pennsylvania were given in tabular form, and in the same table some data on the variation in moisture-and-ash-free calorific values in car samples of coal were included. The greatest deviation in calorific value of any one individual sample from the average of the mine is usually less than 1 per cent. In only two cases in the table did it reach the maximum figure of 1.1 per cent. Obviously the calorific value of samples representing various shipments of coal from the same mine and seam can be calculated with an accuracy of about 1 per cent. by multiplying the average moisture-and-ash-free calorific value of the coal by 1 minus the sum of the moisture and ash of the various individual samples. This method of calculating will not apply to weathered coals which, on account of absorption, have lost some of their original heat value, or to coals that vary considerably in the character and amount of ash and sulphur. In the coals cited in the table the ash is usually less than 12 per cent. and the sulphur less than 2 per cent. Where the sulphur content is larger and more variable, as found in some of the coals of Ohio and Illinois, a further correction for the influence of sulphur should be applied.

Sampling

The chemist makes his analysis on a few ounces of powdered coal. If the analysis is to be of any value, this small sample must have a composition that is an average of the entire lot of coal whose value is to be established. The accuracy of sampling the commercial sizes of coal is limited to the amount and size of the largest lumps of impurities and the quantity of original sample that can be taken without incurring too great a cost. The accuracy of any method of sampling should be frequently tested by taking two or more independent samples, which are reduced and analyzed separately. Ordinarily, the sample sent to the laboratory will weigh from 3 to 5 lb. and will be pulverized to about ¼ in. size. The original gross sample, which may amount to from 500 to 1000 lb., must be pulverized, mixed and quartered in such a manner as to maintain the same relative proportions of coal and impurities until the final 3- to 5-lb. sample is obtained; furthermore, coal has a marked tendency to lose moisture in crushing. This must be avoided as much as possible. The final sample should be placed in a moisture-proof container for shipment to the laboratory. Wooden boxes or sacks should never be used for samples in which moisture is to be determined.

Accuracy of Mine Sampling

During the last nine years the U. S. Geological Survey and its successor, the Bureau of Mines, has analyzed a large number of mine samples of coal, taken in connection with the investigation of coal as it occurs in the mine. A table was included in the paper to show the results from a series of duplicate 3-lb. can samples that were taken by the standard method of the Bureau of Mines. On account of the high percentages of moisture, ash and sulphur and the irregular distribution of the impurities, Illinois coals are unusually difficult to sample, yet, in spite of the high moisture content, the greatest difference of moisture in duplicate samples was only 0.3 per cent., with an average difference of 0.1 per cent. The average variation in ash of the duplicate samples from seven sections in two Pennsylvania mines was 0.1 per cent.; the maximum variation being 0.2 per cent. In the Illinois series the maximum variation was 1.6 per cent., the next highest difference being 0.7 per cent.

Sampling in the Laboratory

In the method used by the Bureau of Mines, moisture loss is avoided by air-drying the 3-lb. sample before pulverizing. The amount of moisture expelled during the air-drying process is recorded and added to the final moisture obtained by drying the powdered sample at 221 deg. F. The air-dry sample is quickly pulverized to 10 mesh by passing through a roll crusher, reduced on a riffle sampler to about 1 lb. and ground to a 60 mesh in a moisture-tight ball mill, which consists of rotating porcelain jars containing well rounded flint pebbles. The final powdered sample is preserved in a rubber-stoppered bottle to prevent change in moisture content.

Usually the laboratory sampling error with respect to ash, by the method just described, is less than 0.3 per cent., and seldom greater than 0.5 per cent. Where careful work is done by the sampler, the 0.5 per cent. limit should not be exceeded.

Incorrect Methods of Preparing Coal Samples

The determination of total moisture by drying a portion of the coarse sample in a steam oven at about 221 deg. F. will give low results, the error increasing with the size of the lumps. The method of drying the coarse sample at temperatures above 212 deg. F. and then pulverizing to a powdered sample for analysis with the assumption that the powdered coal is dry coal, will give quite erroneous results. The powdered sample will never be dry, but will contain from 0.3 to 1 per cent. moisture, which it has either failed to give up while drying in the coarse condition, or has taken up from the atmosphere, while being pulverized. The heat values are directly affected by the errors in the sampling and in the moisture determinations.

Abrasion in Ball Mills

In using any apparatus for pulverizing samples, the amount of contamination from abrasion of the pulverizing surfaces should always be investigated. The addition to the ash content may be found by determining the loss in weight of the grinding surfaces. The results of a number of tests on a ball mill showed only 0.004 per cent. increase in ash due to the abrasion from the pebbles. The extent of abrasion from the porcelain jars was shown in a series of tests to be 0.01 per cent. at the highest, which is less than the analytical error in the determination of ash.

Conclusion

To state definite limits of accuracy for coal analyses is almost impossible. The factors which influence the results are many and variable. They depend on the kind

and quality of coal, the method of sampling and analysis and the skill and experience of the analyst in the special field of coal testing.

With the exception of the volatile matter, fixed carbon and oxygen determinations, the best analytical methods are more accurate than the methods of sampling. The method of taking the original sample is often limited by the commercial conditions. The determination of the heat value with the use of properly standardized calorimeters and thermometers is reliable and comparable. Appreciable errors, when such occur, are due to sampling or a change in the composition of the sample by oxidation or loss of moisture. Finally, a statement of how the sample was taken should always go with the report of analysis. This will enable one who has a knowledge of coal to properly interpret the report.

Avery Automatic Liquid Scales

This weigher is built with an even-arm balance, a beam supporting a weight-hopper at one end and a weight box at the other. It is designed to weigh liquids in unit amounts and record the summation of weights upon a counter, automatically, continuously and accurately, regardless of temperature and inlet pressure.

Liquid enters at the top of the machine through a balanced valve, controlled by levers, into the weigh-hopper in a full stream, but the liquid is brought to a dribble, by reason of the combined weight of levers resting on a projection of the weigh beam, and thus partly closing the inlet valve. The weight of the levers is then transferred to a knife edge and a roller until an exact balance is reached. In traveling to a balance a projection releases a catch holding the hopper in position, and the hopper turns completely over, Fig. 1, because it is supported below the center of gravity. At the same time the inlet valve is closed and the toggle joints connected to the vertical lever are held rigidly in place. When the hopper is brought back to position by the counterweight the toggles are broken. This action opens the balanced valve and a new weighing is begun.

The chamber at the right of the bucket, Fig. 2, insures the release of all liquid. Becoming full, the liquid releases under the hinged plate slower than from the main hopper so that its weight holds the hopper down until all liquid has left. If any remains in this portion, it will drain out through a hole. A compensating lever and weight allow for the liquid in suspension at the time of cutting off the flow, this giving further accuracy.

This liquid weigher has many fields of usefulness. For power plants it automatically weighs and records all feed water passing to the boilers. For oil-burning furnaces, it weighs the amount of fuel oil consumed. The weigher is made by the Avery Scale Co., 726 Monadock Building, Chicago, Ill.

A reduction in electric-power rates has been made by the Ontario Hydro-electric Commission to the municipalities which purchase energy through this commission (which supplies them over its own transmission lines from a Niagara

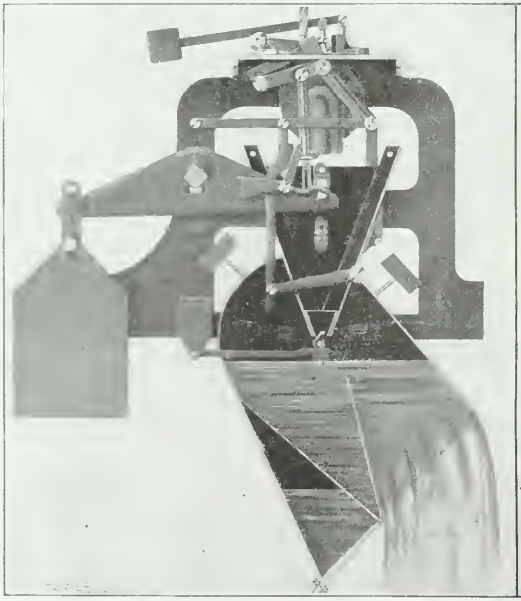


Fig. 1. Dumping Position

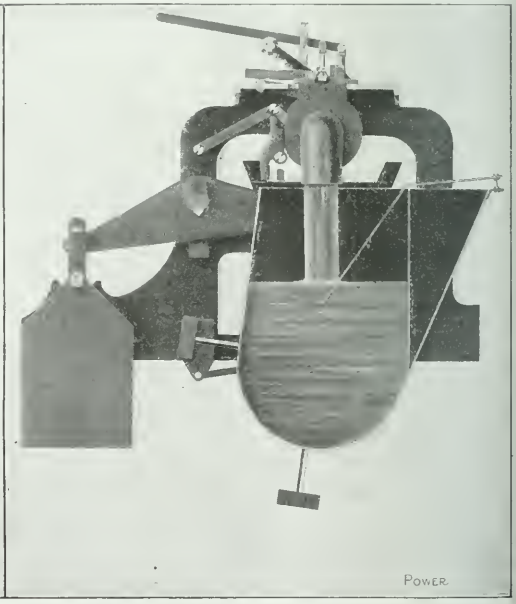


Fig. 2. Filling Position

Falls plant). The new rates mean a decrease of some $100,000 gross income over the present figures. The total connected load of the system is now about 34,000 hp. It is claimed that the new rates are more than sufficient to cover the various charges together with proper sinking-fund installments. There was a yearly surplus of $62,000 at the end of Oct. 31, which sum is only $10,000 less than the whole sinking-fund charges for the first year. It was not planned to burden the pioneer purchasers of energy with sinking-fund and depreciation charges until the year 1914; but before reducing the rates as above noted, deductions for that purpose were made.

NEW PUBLICATIONS

THE METRIC SYSTEM IN A NUTSHELL. By Henry G. Bayer. Thirty-one 4x6½-in. pages; 20 tables of equivalents. Price, 35c. Henry G. Bayer, 232 Greenwich St., New York, N. Y.

This booklet contains 20 tables of equivalents of English and metric units, taken from the larger book by the same author, and reviewed before. It is arranged in a convenient form for the manufacturer and business man who wishes a general idea of the metric system and needs at hand tables to convert easily and quickly the quantities and measurements with which he deals.

THE MODERN GASOLINE AUTOMOBILE: ITS CONSTRUCTION, OPERATION, MAINTENANCE AND REPAIR. By Victor Page. Published by The Norman W. Henley Publishing Co., New York, 1912. Size, 5½x8¾ in.; 693 pages, illustrated. Cloth. Price, $2.50.

A very complete treatise on the modern gasoline automobile, written in a simple, nontechnical, yet convincing style. The general features of design, common to all cars, are first taken up and then the special features are discussed, such as T-head, L-head and sliding-sleeve motors; planetary, progressive and selective transmission; the multiple-disk, cone, band and dry-plate clutch, etc. In this discussion the relative merits of each are pointed out.

Considerable space is also devoted to automobile accessories, such as lighting, windshields, etc., and particularly useful is the advice on the proper maintenance and operation of a car.

It is a book which every car owner who desires to be well informed on automobile practice should read.

ESSENTIALS OF ELECTRICITY—DIRECT CURRENTS. By W. H. Timble. Wiley Technical Series. Published by John Wiley & Sons, New York. Size, 5x7 in.; 271 pages, illustrated; cloth. Price, $1.25.

The aim of this little book is to give the practical man a working knowledge of the underlying principles of direct-current practice; hence all mathematical analyses are avoided and the subject is approached from the physical rather than the abstract viewpoint; in this connection, recourse is made to the water analogy.

The author, who has taught applied electricity in trade schools for several years, has recognized the needs of the practical man in this line and has chosen the extensive use of problems to drive home the text matter. Several examples are worked out after each important topic or statement, and a large number of problems are appended at the end of each chapter. In connection with the latter problems it might have been an aid to the man who is using the book for self-instruction if a list of answers had been given at the back.

All important conclusions and laws are in heavy type, and a summary is given at the end of each chapter. The divisions of the subject covered are: Ohm's law, simple electric circuits, combinations of series and parallel systems, electric power, wire and wiring systems, generators and motors, batteries and wiring diagrams. Considerable space is also devoted to locating and correcting trouble in generators and motors, a most useful subject for operating men. Moreover, the illustrations are well chosen.

In point of criticism may be mentioned several loose statements in the text: On page 15 the author says: "An ammeter is inserted into the circuit, and becomes a part of the circuit and receives the full current of the circuit"; the subsequent illustrations and problems bear this out.

While this would apply to circuits handling very small currents, where large currents are to be handled, such as on a switchboard, ammeter shunts would have to be employed. The author, however, makes no mention of shunts.

Again, on page 129, is the statement, "Self-excited machines sometimes change their polarity when not in use." While this is true, it would leave the reader to infer that they never change their polarity when in use—a condition which frequently happens.

On page 108 the author states that the neutral wire is usually the same size as each of the other two. As a matter of fact, it is usually half the size of each of the outside wires, and sometimes less.

The following statement is also made:

If electric power is generated outside the machine and is brought to it, and if this power puts the machine in motion and thus runs other machinery, the machine is called a motor. If the machine derives its mechanical power from some source outside itself, and delivers electric power, it is called a generator. The term dynamo includes both generator and motor.

While any direct-current generator may be run as a motor, it seems a misnomer to apply the term "dynamo" to a motor. Common usage has made the dynamo synonymous with generator, and even the dictionaries (both electrical and general) define a dynamo as a machine for converting mechanical into electrical energy by magneto-electric induction.

On the whole, the merits of the book greatly outweigh its defects, and it should prove very useful to the man who must acquire a working knowledge of the subject in a short time.

Midwinter A. I. E. E. Convention

The midwinter convention of the American Institute of Electrical Engineers, held Feb. 26 to 28, was devoted exclusively to a discussion of data bearing upon a revision of the present Standardization Rules, which have been found inadequate to cope with present requirements in the electrical field.

In all, 45 papers were presented—the large number making it necessary to read most of them in abstract or by title only. The papers were classified under four groups, the first dealing with heating, heat measurements and rating by heat; the second with methods in determining losses in apparatus; the third with methods of testing apparatus for performance; and the fourth with miscellaneous subjects relating to rating.

The discussions, both written and oral, were numerous, and for the most part very largely of a constructive nature.

The Standards Committee, under whose direction the convention was held, deserves credit for the businesslike manner in which the meeting was conducted and the large number of papers disposed of.

The convention was concluded with a reception and dance at the Hotel Astor, on the evening of Feb. 28.

National Tube Co.'s Book of Standards

To the engineer who needs practical, accurate information concerning pipes, tubes, joints, valves, fittings, etc., and who desires a strictly pipe handbook, the 1913 revised edition of the National Tube Co.'s "Book of Standards" will be of immense value. It is not a catalog nor padded with advertising matter. This edition is larger and more complete that the older one, contains 559 pages, is printed on Canterbury Bible paper and will fit the pocket readily. The index has about 4000 references, and all the headings are cross-indexed.

A descriptive article covers the main process of manufacturing both welded and seamless tubes and gives much information on the threading, durability, physical properties, etc., of both National pipe and Shelby seamless steel tubes. Weights, dimensions, threads per inch, test pressures, sections of joints, specifications, etc., of the various kinds of pipes and tubings made are also given as well as a valuable article on protective coating, Matheson joint pipe and Converse joint pipe.

Several pages contain tables of lap-weld and seamless tubes, upset and expanded, wrought pipe bends, butted and strapped joints, pump joints, valves and fittings, including various kinds of nipples and flanges, hand railings and ladders, working barrels, cylinders, Shelby seamless specialties, Shelby seamless cold-drawn trolley poles, tables of physical properties of Shelby seamless steel tubes and of carbonic acid gas, Briggs' standard tolding power of boiler tubes and thermal expansion of iron and steel tubes.

The articles on the strength of tubes and cylinders under internal fluid pressure and collapsing pressures are from papers by Prof. R. T. Stewart, of the University of Pittsburgh. Several of the formulas are compared, and results of actual tests are given. These are also tables which show the probable collapsing and bursting strengths of standard tubes. These articles and tables will prove of immense benefit in connection with boiler engineering problems.

An article on safety factors and safe working stresses shows through what ranges values should be used for safe operation. Information is also given on water, gas, steam and air insofar as they concern tubular products.

The many tables include fifth roots and fifth power; decimals of a foot for each $\frac{1}{64}$ in.; decimals of an inch for each $\frac{1}{64}$; wire and sheet metal gages in approximate decimals of an inch. Other features are proportions of screw threads, nuts and bolt heads, area and weight factors for tubes and pipes; special tests by which to find directly the weights of nearly all sizes and thicknesses of steel tubing up to 36 in.; tables showing properties of tubes and round bars, with an explanatory article, and giving various physical properties, including circumference, area, weight, surface in square feet, values, moment of inertia, radius of gyration, etc., for tubes and round bars up to and including 36 in.

The metric system is included with conversion methods for most of the more commonly used measures, including temperature, and a glossary of terms used in the pipe and fittings trade. The meanings of the less well known words in the trade are defined.

The book is published by the National Tube Co., Pittsburgh, Penn., and will be sent on receipt of $2.

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To Cooperate for Public Betterments

Arthur Williams, of the New York Edison Co., and chairman of the public policy committee of the National Electric Light Association, was the host, on Tuesday evening, Feb. 18, of a dinner in the Union League Club, New York City, to a number of representatives of electric lighting and street railway companies from all over the country. The dinner was followed by an informal discussion on ways and means of coöperating with the public in the management of public utilities.

Gen. George H. Harries, president of the Louisville Lighting Co., referred to what he called a partnership with the companies and the public and said that only in this way could the best coöperation be obtained.

After some discussion of minimum wages and old age pensions, Mr. Williams said that he did not like the term "old-age pensions," but preferred "service annuities." What the old employees received was the result of rendering service as well as performing work.

Some of those there were Frank Hedley, vice-president and general manager of the Interborough Rapid Transit Co.; Thomas N. McCarter, president of the Public Service Corporation of New Jersey and chairman of the committee on public relations of the American Electric Railway Association; Patrick Calhoun, president of the United Railroads of San Francisco; Oscar T. Crosby, president of the Trenton & Mercer County Traction Co.; James H. McGraw, president of the McGraw Publishing Co.; William H. Heulings, Jr., assistant secretary of the J. G. Brill Car Co.; C. Loomis Allen, president of the Newport News & Old Point Comfort Ry. & Electric Co.; C. C. Pierce, vice-president of the Providence & Fall River Street Ry. Co.; J. H. Pardee, president of the J. G. White Management Corporation and H. C. Donecker, secretary and treasurer of the American Electric Railway Association.

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Gas Engine Cylinder Head Blows Out

When starting a gas engine in the factory of the S. L. Pierce Shoe Co., Cleveland, Ohio, at 7:30 a.m., on Feb. 19, the cylinder head was blown out. The engine was about 12 years old. Paul Cooley, the engineer, was thrown about 15 ft., and injured on the head and back. The fireman was not seriously injured. The engine is said to operate on natural gas, and the explosion was due to backfiring. The owners of the engine refused to supply any other information.

SOCIETY NOTES

At the special meeting of the American Museum of Safety on Friday evening, Feb. 21, at Delmonico's, New York City, the Harriman medals were discussed. The gold medal will be awarded by the Museum of Safety to the railroad in the United States which will have made the greatest progress in safety and accident prevention, first in safeguarding the traveling public, and second, in preventing accidents among employees. The silver medal will be awarded to an operative head, such as a division superintendent who has himself accomplished notable work along safety and accident prevention lines. The bronze medal will be awarded to a switchman, a brakeman or a yardman who has performed some kind of service or in some way contributed to the safety of the public or his fellow workmen. The medals will be awarded annually in January, the first presentation being in 1914. The committee appointed by President Arthur Williams to take charge of all matters relative to the medal consists of President Hadley, of Yale; the U. S. Commissioner of Labor; Secretary W. F. Allen, of the American Railway Association; Samuel O. Dunn, eidtor of the "Railway Age Gazette," and Franklin K. Lane, chairman of the Interstate Commerce Commission. The Harriman medal is the fifth which the Museum now awards annually. Among the honorary guests at the dinner and meeting were H. L. Doherty, James Speyer, Dr. F. L. Hoffman, Dr. William H. Tolman, Dr. Norman E. Ditman, A. A. Hopkins, Dr. Charles A. Doremus, T. Commerford Martin and A. A. Anderson.

OBITUARY

WILLIAM HENRY WHITE

On Feb. 27, Sir William Henry White the originator of the modern battleship, died suddenly in London after a stroke of apoplexy.

He was born in Devonport in 1845. He was in the constructive department of the Admiralty from 1867 to 1883, and rose to the rank of chief constructor; he was professor of naval architecture at the Royal School of Naval Architecture and the Royal Naval College from 1870 to 1881; he organized and directed the warship building department of Armstrong & Co., at Newcastle, from 1883 to 1885; he was director of naval construction and assistant controller of the royal navy from 1885 to 1902, and during that time designed many of Great Britain's big fighting ships.

Because of ill health Sir William resigned his office and was awarded a special grant of money by vote of Parliament in recognition of his services to the navy. He was a consulting designer of the "Mauretania" for the Cunard Steamship Co.

On his retirement from the public service Sir William White took a leading part in the proceedings of the principal British engineering societies, and was particularly interested in the promotion and organization of technical education. He was president of the Institution of Civil Engineers, the Mechanical Engineers, the Marine Engineers, the Institute of Metals, and the Junior Institution of Engineers.

Many engineering societies in Great Britain and abroad have enrolled him as honorary member. Among these are the American societies of Civil Engineers, Mechanical Engineers and Naval Architects, the Canadian Society of Civil Engineers, and the Association Technique Maritime of France. The John Fritz Medal for 1911 was awarded to Sir William White "for achievements in naval architecture" by the special board appointed by the four great American engineering societies. At home, he was an honorary member of many engineering societies, including the Society of Engineers, the Engineers and Shipbuilders in Scotland, the North East Coast Institution of Engineers and Shipbuilders, the Liverpool Engineering Society and the Aberdeen Association of Civil Engineers; a fellow of the Royal Society, the highest scientific distinction possible to a British citizen; a fellow of the Royal Society of Edinburgh and a member of the Royal Academy of Sciences in Sweden. Honorary degrees were conferred upon him, including the doctorate of science of Cambridge and Durham in England, and of Columbia University in the City of New York; the doctorate of laws in Glasgow; the doctorate of engineering in Sheffield University. As the result of his persistent advocacy, professorships of naval architecture have been founded in the universities of Liverpool and Durham.

PERSONALS

Ernest B. Lloyd, M. E., has accepted the position of chief engineer of the Chicago State Hospital, at Deeming, Ill. Mr. Lloyd was until recently with the Kankakee State Hospital.

John J. McDonald, a salesman for the William B. McVicker Co., New York City, for the past three years, has accepted a position with J. L. Quimby & Co., of that city, in a similar capacity.

John Fritz, the eminent engineer and iron master, gave his residuary estate, amounting to about $150,000, to Lehigh primarily as an endowment fund for the maintenance of the Fritz Engineering and Testing Laboratory. Mr. Fritz, who was a trustee of Lehigh from its founding in 1866, gave the laboratory to the university in 1910. It is one of the best equipped of its kind in the world, and its construction and equipment were personally supervised by Mr. Fritz.

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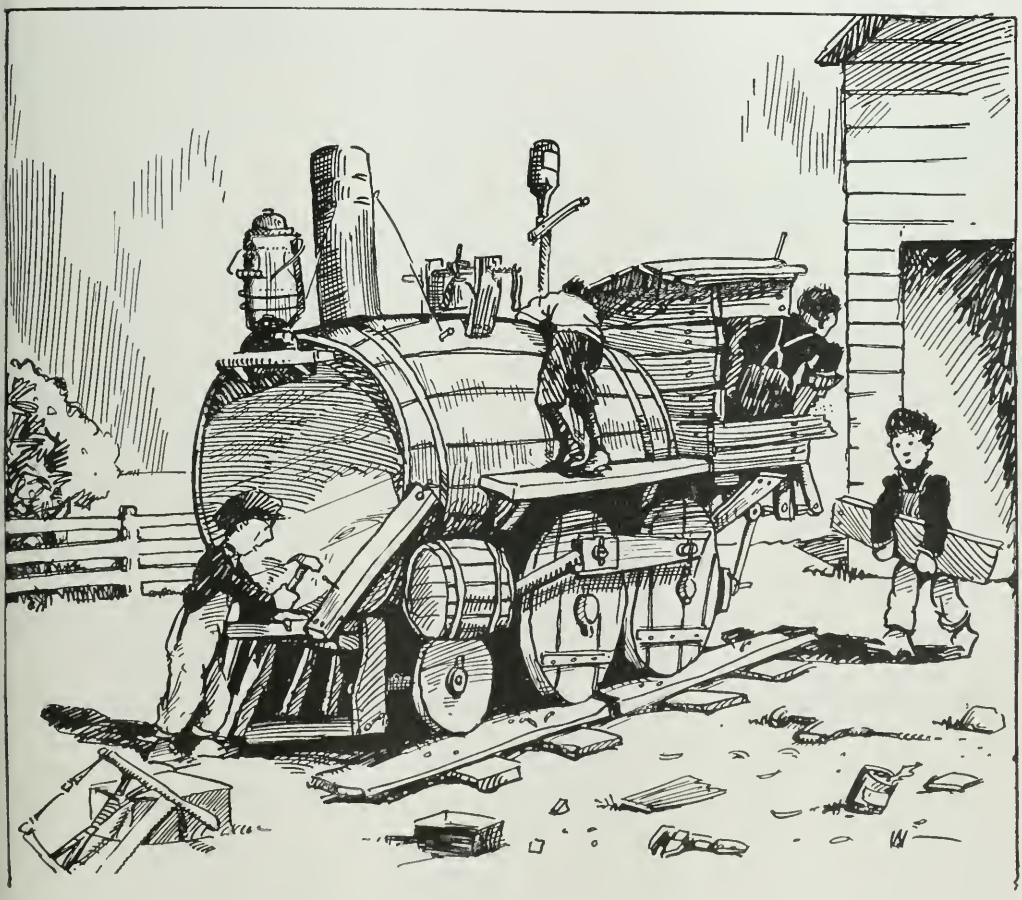
J. G. White & Co., Inc., believing that the separate incorporation and independent management of its three major departments will increase the general efficiency of its work, has formed, as subsidiary companies, the J. G. White Engineering Corporation and the J. G. White Management Corporation. The new companies have acquired the good will, contracts, equipment and other assets of the engineering, construction and management departments of the present company. J. G. White & Co., Inc., will continue as an active financing and owning company in the general field of engineering and public utility enterprise.

POWER

Vol. 37 NEW YORK, MARCH 18, 1913 No. 11



ENGINEERS OF TOMORROW

Drawn by Delevan E. Whaley, Reading, Mich.

Lake Shore Generating Plant

By A. D. Williams

SYNOPSIS—This new turbine plant of the Cleveland Electric Illuminating Co., located on the shore of Lake Erie, has at present a capacity of 61,000 kw. with provision for extension to more than double this amount. The present article deals with the plant in general and will be followed with two other installments treating of special phases of the design and equipment.

Service demands indicated that the Cleveland Electric Illuminating Co., would outgrow its generating capacity and there was no further space available at the original plant on the flats. This and the undesirability of the Cuyahoga River water led the management to seek a site upon the shore of Lake Erie where the water supply would be unlimited and where ample room would be available for future extension. A ten-acre site was secured at the foot of East Seventieth St., running back from the lake about one thousand feet to the main line of the Lake Shore R.R. and the construction of the Lake Shore generating plant was started about three years ago. A portion of the plant has been in operation for about a year, and a fifth unit of 15,000 kw. capacity has just been added. The two 9000-kv.-a. units in this plant were first delivered and placed in operation in the old plant and were afterward removed to the new plant when the installation of the two 14,000-kv.-a. units enabled the Lake Shore plant to carry a large part of the load.

The general plan of the plant, Fig. 2, shows only the north or lake end of the property and the service tracks in the yard which connect with the Lake Shore R.R. The shore of the lake, at this point, forms a steep bluff rising from close to the water's edge to a height of nearly 50 ft. above the water level. The southern portion of the property is level and a portion of it is utilized for coal storage. The generating plant is located at the foot of the bluff on a portion of the site which lays beyond the old shore line of the lake. The building stands upon a concrete mat substructure inclosed in a steel sheet-pile cofferdam, and is built of brick with granolithic trimming. A large proportion of the wall area is of glass, admitting light to all parts of the plant.

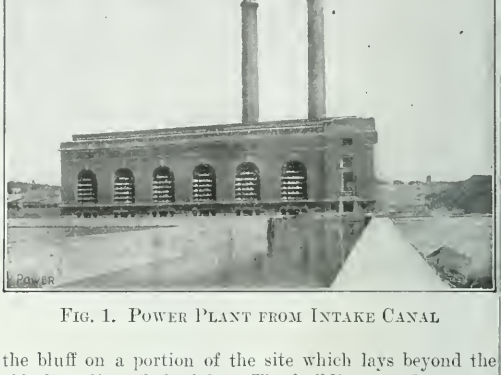


Fig. 1. Power Plant from Intake Canal

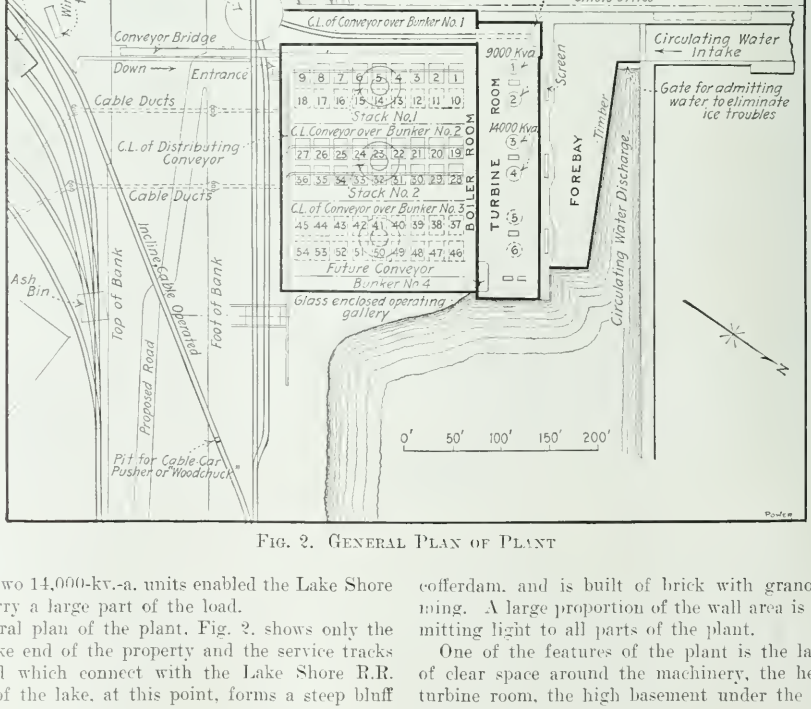

Track Scale for Coal
Winding Engine for Incline
Turntable
143'-7" to Storage Battery Room in Basement
Glass enclosed gallery, Chiefs Office
C.L. of Conveyor over Bunker No. 1
Conveyor Bridge
Down → Entrance
Cable Ducts
C.L. of Distributing Conveyor
Cable Ducts
Ash Bin
Top of Bank
Incline Cable Overhead
Foot of Bank
Proposed Road
Pit for Cable Car Pusher or Woodchuck
9 8 7 6 5 4 3 2 1
18 17 16 15 14 13 12 11 10
Stack No. 1
C.L. Conveyor over Bunker No. 2
27 26 25 24 23 22 21 20 19
36 35 34 33 32 31 30 29 28
Stack No. 2
C.L. of Conveyor over Bunker No. 3
45 44 43 42 41 40 39 38 37
54 53 52 51 50 49 48 47 46
Future Conveyor
Bunker No. 4
Glass enclosed operating gallery
BOILER ROOM
TURBINE ROOM
9000 Kva
14000 Kva
Screen
FOREBAY
Timber
Circulating Water Discharge
Circulating Water Intake
Gate for admitting water to eliminate ice troubles
0' 50' 100' 150' 200'
Power

Fig. 2. General Plan of Plant

The features of the plant is the large amoun of clear space around the machinery, the height of th turbine room, the high basement under the boilers, an

the wide firing aisles. However, this plant compares very favorably on a space and volume basis with other large plants, as indicated by the following approximate figures:

	Area, Square Feet	Volume, Cubic Feet
Turbine room	28,560	2,252,000
per kilovolt-ampere	0.396	30.43
Boiler room	53,920	3,740,900
per kilovolt-ampere	0.729	50.55
per boiler horsepower	1.664	115.60
Total ground area	82,480	5,992,900
per kilovolt-ampere	1.114	89.88

In general arrangement the Lake Shore plant is somewhat similar to the Fiske Street station in Chicago. The boiler-firing aisles are at right angles with the turbine room. The self-supporting steel stacks with their linings are carried upon the steel framing of the building, and the breechings are placed on the roof of the building over the boilers. The space over the firing aisles is covered by a large hopper-bottom coal bin in a monitor between the stacks.

has been made, the operating gallery, which is now located at the extreme east end, will be in the center.

The level of Lake Erie, at Cleveland, is subject only to small variations, which permits the basement-floor level being placed only one foot above the lake level without incurring any danger from flooding. The turbine floor is 12.5 ft. above the lake and the boiler floor 8.5 ft. higher. This arrangement permits running the boiler-room steam piping below the floor, in the basement, and gives a practically level run to the turbines.

The only machines below the turbine-room floor are the hotwell or wet-vacuum pumps, which have to be placed below the level of the bottom of the condenser, and the surface condensers. The turbine-room floor is slightly below the lowest steam stage of the turbine. All the boiler-feed pumps, high- and low-pressure oil pumps, the dry-vacuum and circulating pumps are in the turbine room.

The generators are of the down-draft ventilated type,

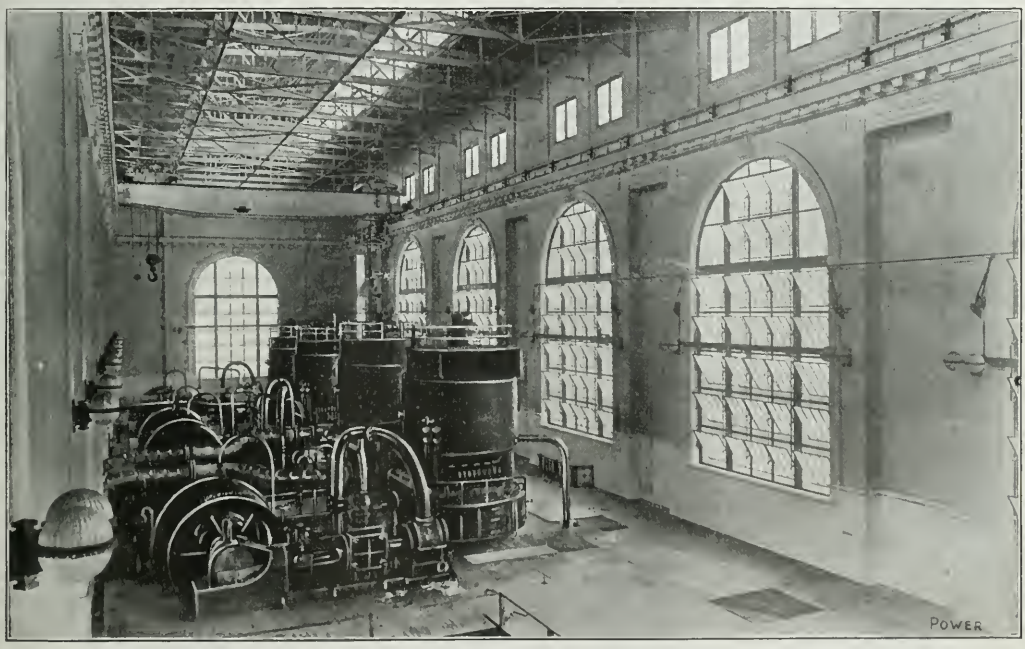


FIG. 3. VIEW OF TURBINE ROOM, SHOWING 14,000-KV.-A. AND 9000-KV.-A. UNITS

The only switching equipment in the power plant is that necessary for the control of the generating equipment, the exciters and the station lighting. The distribution is controlled from a separate switchhouse.

The machinery and boilers are arranged in symmetrical groups, each consisting of two generating units and their auxiliaries in the turbine room and the boilers, stack and bunker supply in the boiler room. Each group is practically an independent unit power plant, three such units forming the equipment, when complete, in the present building, while the space available for extension will permit the installation of four similar unit groups to the east of the present structure. When this extension

the air supply being drawn in from the turbine room through an inlet at one side of the machine just below the top platform, passing down through the air ducts in the machine and being discharged into the room through outlets in the distance piece over the top of the turbine. This method of ventilation avoids the large air ducts leading up to the top of the generator, but the floor framing and plates are so arranged that air may be drawn from outside of the building should this become necessary. The approximate air circulation through the turbines is 10,000 cu.ft. per min. for the 9000-kv.-a. units and 50,000 cu.ft. per min. for the 14,000-kv.-a. units. These machines are guaranteed to operate at 85 per cent. power

EQUIPMENT OF LAKE SHORE GENERATING PLANT

	Equipment	Type	Service	Volts	Amperes	R.p.m.	Size	Number Stages	Capacity	Temperature and Pressure	Maker and remarks
2	A. C. Generators	3-phase 60-cy vert.	Main units 1 & 2	11,431	455	720			9,000 kv.a		G. E. Co.
2	A. C. Generators	3-phase 60-cy vert.	Main units 3 & 4	11,431	706	720			14,000 kv.a		G. E. Co.
1	A. C. Generator	3-phase 60-cy vert.	Main unit 5	11,431	756	720			15,000 kv.a		G. E. Co.
2	Turbines	Curtis vert.	Main units 1 & 2			720		5		215 lb. 125° F. Superheat	G. E. Co.
2	Turbines	Curtis vert.	Main units 3 & 4			720		5		215 lb. 125° F. Superheat	G. E. Co.
1	Turbine	Curtis vert.	Main unit 5			720		5		125° F. Superheat	G. E. Co.
2	Surface condensers	Base type two-pass	Units 1 & 2				16,000 sq.ft.		140,000 lb. steam per hr.	28 in. vac. 70° F. circ. water	Wheeler Cond. & Eng. Co.
2	Surface condensers	Base type two-pass	Units 3 & 4				25,000 sq.ft.		224,000 lb. steam per hr.	28 6 in. vac. 60° F. circ. water	Alberger Cond. Co.
1	Surface condenser	Base type two-pass	Unit 5							28 6 in. vac. 60° F. circ. water	Alberger Cond. Co
2	Dry vacuum pumps	Corliss	Units 1 & 2			75–110	18 & 30x18	1		215 lb.	Flash port in air cylinder. Wheeler Cond. & Eng. Co. C. & G. Cooper Co., steam end.
2	Circulating pumps	Centrifugal double suction	Units 1 & 2			75–110	30 in.	1	24,000 gal.		Wheeler Cond. & Eng. Co.
2	Dry vacuum pumps	Corliss	Units 3 & 4			100–150	20 & 34x24	1		215 lb.	Flash port in air cylinder. Alberger Cond. Co
1	Dry vacuum pump	Corliss	Unit 5								Alberger Cond. Co
2	Circulating pumps	Centrifugal double suction	Units 3 & 4			100–150	36 in.	1	30,000 bal.		Alberger Cond. Co
1	Circulating pump		Unit 5								Alberger Cond. Co
2	Hot well pumps	Centrifugal	Units 1 & 2			2000	4 in.	1	300 gal.		Wheeler Cond. & Eng. Co.
2	Turbines		Units 1 & 2			2000		1	10 hp.		Terry Turbine Co.
3	Hot well pumps	Centrifugal	Units 3, 4 & 5			2220	6-in. suction 5 in discharge	1	675 gal.		Alberger Cond. Co
3	Turbines		Units 3, 4 & 5			2220		1			Terry Turbine Co.
2	Free exhaust valves		Units 1 & 2				30 in.				Crane Co.
3	Free exhaust valves		Units 3, 4 & 5				36 in.				Crane Co.
6	Pumps	Centrifugal	Boiler feed			3–2000 3–1700	6 in.	4	625 gal.		Suction head 5 ft. Discharge head 320 ft Platt Iron Works Co.
3	Turbines		Boiler feed			2000		1	180 hp.	175 lb	2 in. back pressure. Terry Turbine Co
3	Turbines		Boiler feed			1700		1	150 hp.	175 lb	Terry Turbine Co.
8	Pumps	Duplex plunger	Step bearing				12x2½x12				Dean Bros. Outside packed.
5	Accumulators	Vertical	Step bearing				12 in.x13 ft.		850 lb.		R. D. Wood & Co.
8	Pumps	Duplex	Lubrication				6x4x6				Dean Bros.
4	Pumps	Vertical	Oil returns								Dean Bros.
1	D. C. generator	Interpole	Exciter	140	900	2500			125 kw.		G. E. Co
1	Turbine	Curtis horizontal	Exciter			2500				215 lb.	G. E. Co.
2	D. C. generators	Interpole	Exciter	125	1600	500–514			200 kw.		G. E. Co.
2	Motors	3-phase	Exciter	2200	72	500–514			300 hp.		G. E. Co.
1	Storage battery		Exciter	140			60 cells				Electric Storage Battery Co. 60 cells and 20 end cells
1	D. C. generator	Interpole	Booster for battery	80 230	300	500			67 5 kw.		W. E. & M. Co.
1	Motor	3-phase	Booster set	2200		500			100 hp		W. E. & M. Co.
1	D. C. generator	Interpole	Ashes	250	140	850			35 kw.		Lincoln Electric Co
1	Motor	3-phase	Ashes	230	126	850			60 hp.		Lincoln Electric Co.
1	Crane	Overhead traveler	Turbine room								Cleveland Crane & Eng. Co.
1	Pump	Volute double suction	Sump					1	150 gal.		10-ft. head. Jeansville Iron Works
1	Motor	3-phase	Sump pump	220	35 5	1800			15 hp.		G. E. Co.
1	Air compressor						10x10				Clayton Air Compressor Co. Morse chain drive.
1	Motor	3-phase	Air compressor	220		900			25 hp.		Crocker-Wheeler Elec. Co.
5	Heaters	Closed, vertical	Boiler feed								Wheeler Cond. & Eng. Co. Alberger Cond. Co.
27	Boilers	Stirling	Main units				6000 sq.ft.		600 hp	215 lb.	B. & W. Co.
27	Superheaters	Foster	Boilers				800 sq.ft		15,250 lb. per hr	100° F.	Power Specialty Co.
27	Stokers	Chain grate	Boilers				10x11 110 sq.ft		20-40 lb. per sq.ft per hr.		2 to 10 in. travel per min. 2 to 4 in. draught. Green Engineering Co.
9	Engines	Slide valve	Stokers								
2	Chimneys	Steel lined	Boilers				18.5x216 ft.				E. H. Waches, (Chicago) 246 ft. above grates.
37	Water columns		Boilers								Jas. McNeil Bros. Co
27	Draught regulators		Boilers								D. T. Williams Valve Co.
27	Scales		Coal hoppers				6 ton				Howe Scale Co.
	Valves		Steel body								Crane Co. & Nelson Valve Co.
	Piping		Soft steel								Pittsburgh Piping & Equip. Co.
1	Turntable		Switching								Detroit Air Motor Tractor
3	Conveyors	30-in. belt	Bunkers				200 ft. long		300 tons per hr., 400 ft. per min.		C. O. Bartlett & Snow
3	Motors	3-phase	Conveyor	220					25 hp.		G. E. Co.
1	Conveyor	30-in. belt	Distributing				250 ft. long		300 tons 400 ft. per min.		C. O. Bartlett & Snow
1	Motor	3-phase	Conveyor	220							G. E. Co.
1	Conveyor	30-in. belt	Incline				302 ft. long		400 ft. per min.		C. O. Bartlett & Snow
1	Motor		Conveyor	220					50 hp.		G. E. Co.
2	Crushers	4-roll					24x26 in.		75 ton per hr.		C. O. Bartlett & Snow
2	Motors	3-phase	Crushers	220		865			75 hp.		G. E. Co.
2	Feeders	Double-plunger	Crushers								C. O. Bartlett & Snow
2	Motors	3-phase	Feeders	220		865			15 hp.		G. E. Co.
1	Track scale		Track hopper						150 ton		Standard Scale & Supply Co.
1	Crane	Steam locomotive	Yard								Browning Eng. Co.
1	Bench board		Main units								Walker Elec. Co.
1	Switchboard		Exciter								Walker Elec. Co.

factor with a temperature rise of less than 50 deg. C. The full-load excitation current is as follows:

	9000-kv.a. Units	14,000-kv.a. Units
Exciting current, unity power factor..	355 amp.	375 amp.
	90 volts	85 volts
Exciting current, 80 per. cent power factor.	435 amp	460 amp.
	110 volts	105 volts

Direct current for this purpose is supplied by two motor-generator sets and one turbo-exciter unit. A storage battery is provided to supply current should the generators fail or be shut down for any reason. This battery normally is floated on the exciter busbars. An independent motor-generator set is installed for charging the battery and the possibility of any interruption in the field excitation while the battery is being charged is taken care of by an automatic switch which disconnects the charging set and throws the battery on the busbars if the current supply fails. Reverse-current relays are connected in the exciter-generator leads and operate the circuit-breakers connecting them to the busbars. The lighting circuits of the plant are sectionalized so that a sufficient number of lamps to partially light all parts of the plant can be connected with the exciter battery in case the other sources of energy fail.

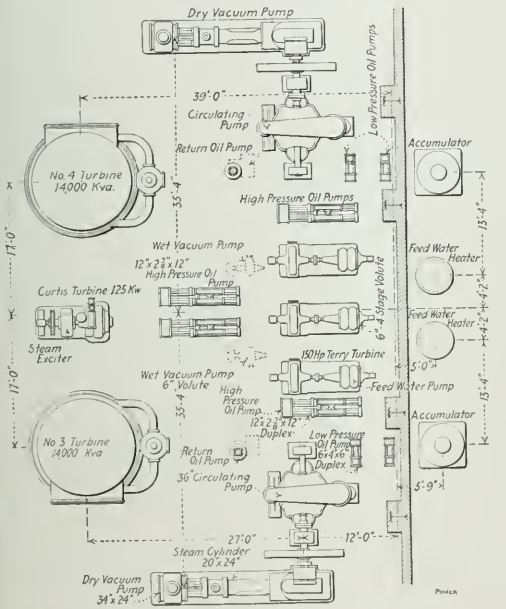


Fig. 4. One Turbine Group with Auxiliaries

It has been found undesirable, if not practically impossible, to hold the convention of the National Electric Light Association later than June, on account of certain constitutional provisions. It has been decided, therefore, to hold the 1915 N. E. L. A. convention during the week of June 14, at San Francisco.

the plant can be connected with the exciter battery in case the other sources of energy fail.

One of the peculiar features of this plant is the use of an inclined plane and a turntable to facilitate the installation of machinery. The bluff at this point would have given a 50 per cent. grade about 100 ft. long if the switch track had been run directly into the building. A slope as steep as this would be extremely difficult to operate with heavy carloads and a runaway would have seriously damaged the structure. In order to minimize the risk of operation and the possibility of damage the cable-operated incline was run diagonally down the bank, reducing the grade to about 10 per cent., and the cars are switched back along the shore side of the building where the boiler-room floor comes about level with the platform of the car. The turntable became necessary with this trackage arrangement in order to permit loaded cars being run into the turbine room where the heavy parts can be unloaded by means of the crane.

San Francisco Conventions in 1915

Arrangements are being made for holding the annual conventions of engineering societies in San Francisco during the exposition period in 1915. Among these are the conventions of the International Electrotechnical Commission, during the week of Sept. 6; International Electrical Congress, week of Sept. 13; General Engineering Congress, week of Sept. 20; and International Gas Congress, week of Sept. 27. It is probable that the American Electric Railway Association will hold its convention during the week of Oct. 4.

Fig. 5. Showing Auxiliaries

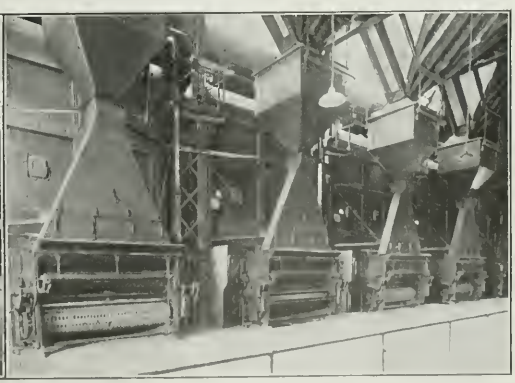


Fig. 6. Well Lighted Firing Aisle

Jacketing Applied to Steam Cylinders

SYNOPSIS—As a number of inquiries have been received relative to steam jacketing, we believe the following extract from an article by Dr. Hubert Hanszel, which appeared some time ago in Zeitschrift des Vereines Deutscher Ingenieure, will be of interest. Among other things, are shown the effects of superheated steam with and without jacketing, the effects of partial jacketing and the economy of jacketing with simple, compound- and triple-expansion engines.

The test was made a few years ago on a 150-hp. Görlitz triple-expansion engine at the Technical University of Berlin for the purpose of determining the effect of steam jacketing and other important heat phenomena in the working cycle of the steam engine.

In this case it was particularly important to accurately determine the condensate in the jackets and receivers. The usual arrangement with traps, the discharge from

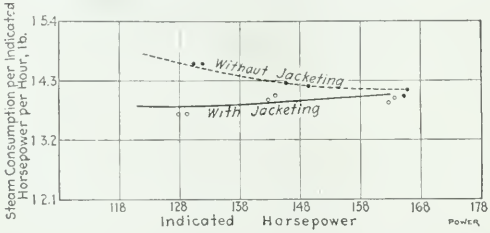


FIG. 1. HOURLY CONSUMPTION OF SATURATED STEAM

which is led off through cooling coils, usually gives too high a value; hence the condensation was collected in closed tanks with water columns and discharged through cooling coils under its own pressure. For the second receiver, in which generally a partial vacuum prevailed, two such tanks were used consecutively.

To prove the correctness of the tests, complete heat balances were established. The good agreement of the losses due to radiation, flow and conduction which appeared as the difference between the measured heat volume supplied and that credited, is a proof of the accuracy of the tests.

It was important to determine the apportionment of these external losses among the individual cylinders because there is thus presented the possibility of knowing the intermediate condition of the steam. To that end a radiation test was made with the engine at rest and the jacket heated. As the greater part of the surfaces, responsible for these losses, were thus under the same temperature as in regular operation an approximation of actual conditions was realized. As a result there appeared as hourly heat losses in the high-, intermediate- and low-pressure cylinders, respectively, 31,744, 30,950 and 32,567 B.t.u.; the last including the exhaust pipe.

In this particular case, with jacketing the quality of the steam in the receivers never went below 0.95, while without jacketing it fell to 0.91. Draining the receivers raised this about 0.01 to 0.05, but there remained constantly 1 to 5 per cent. water in the steam. Still the engine ran uninterruptedly even with the high water content of 9 per cent. However, the best of drainage should be sought as wet steam exercises an unfavorable influence in loss of heat in the cylinders. So long as the walls are covered with deposited moisture, heat exchange is active, as large volumes of heat are withdrawn from the walls for its reëvaporation.

For the series of tests made with saturated steam, Fig. 1 shows the steam consumption referred to the indicated load. It appears from this that at the highest duty there was practically no difference in the steam consumption between jacketing and no jacketing, while with decreasing load and without the jacket the consumption increased as opposed to its decrease with the jacket.

CYLINDER EFFICIENCY*

Although the effects of clearance, wire-drawing at admission and at release, pressure drop during passage of the steam from cylinder to cylinder and possible leakages are all functions of cylinder efficiency, the heat exchange with the cylinder walls may be accepted as the largest factor, because by comparison the other losses, in the same engine and within not too wide limits, can be assumed as constant. The tests confirmed this assumption as the cylinder efficiency is in intimate agreement with the quality of the steam at the beginning of expansion.

The weight and quality of the working steam being given for all the intermediate stages the individual cyl-

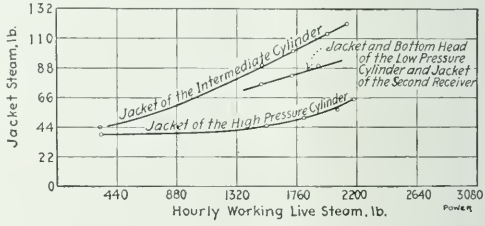


FIG. 2. JACKET STEAM DEPENDENT ON WORKING LIVE STEAM

inder efficiencies can be determined and it is thus possible to judge of the effect of the jacket heating on each cylinder.

In combination with wet steam, the effect of pressure drop on the heat-transferring side of the cylinder walls is further proved by the noticeable showing in Fig. 2, that with increasing cutoff the jacket condensate increases, notwithstanding the higher average wall temperature. This was the case for all three cylinders, as is evident from the curves plotted to show the jacket consumption as dependent on the weight of the working steam. It would seem that in consequence of the higher temperature in the interior of the cylinder the quantity of jacket steam should decrease with increasing cutoff, but the reverse appears to be the case.

PARTIAL JACKETING

Based on the separate cylinder efficiencies it can generally be determined what effect partial jacketing has on

*The term "Cylinder Efficiency" is used here as the equivalent of the German "Gütegrad," which expresses the fractional value:

$$\frac{\text{Steam consumption in a "no-loss" engine with incomplete expansion}}{\text{Steam consumption in the actual engine}}$$

the steam consumption. With jacketing for the high-pressure cylinder an increased duty of about 3 per cent. of the total duty can be expected from a 2.5 per cent. greater expenditure of jacket steam. If the jacket heating be omitted for the high-pressure cylinder alone the steam consumption would not be materially changed.

For the intermediate cylinder an expenditure for jacket steam of about 5 per cent. of the total steam improves the cylinder efficiency about 11 per cent., or referred to the complete engine about 5 per cent., and thus here too the steam consumption would not be particularly influenced by the omission of jacketing. On the contrary, in the low-pressure cylinder with the jacket steam representing only 2.5 per cent. of the total steam the cylinder efficiency is improved about 20 per cent. and the engine duty is increased approximately 8 per cent. Thus, doubtless, only the omission of jacketing from the low-pressure cylinder materially raises the steam consumption.

In short, from the foregoing the influence of the jacket on the three cylinders considered separately is as follows: The heating of the high-pressure cylinder has little effect, but the heat operates for good in the succeeding cylinders. Jacketing of the intermediate cylinder is more effective. Both the high and the intermediate jackets are of immaterial influence on the total efficiency, whereas heating of the low-pressure cylinder raises its efficiency to such an extent that, nothwithstanding the non-utilization in the higher stages of expansion, the total efficiency becomes greater.

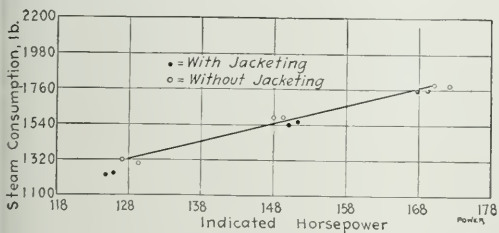


FIG. 3. HOURLY CONSUMPTION OF SUPERHEATED STEAM

To determine by direct measurement the effect of partial jacketing on the steam-consumption, tests were made at the high load (170 hp.), which confirmed the foregoing statements.

SUPERHEATED STEAM WITH AND WITHOUT JACKETING

Two series of comparative tests were made with superheated steam with and without jacket heating and at the same loads as with saturated steam, namely, 130, 150 and 170 hp. Within the limits of the investigation the hourly steam consumption with and without jacketing was the same (see Fig. 3). This is not surprising as here, in the high-pressure cylinder, the influence of the jacket on the initial loss disappears through the effect of superheating. Jacket heating of the high-pressure cylinder was applied for the higher loads, but it did not suffice to even cover the exterior heat losses by radiation, etc. For the smaller loads it was not used. Thus above all, in addition to the effect of jacketing the intermediate- and low-pressure cylinders, the weight at cutoff in the high-pressure cylinder has bearing on the steam consumption.

The dependence of the efficiency of the high-pressure cylinder on the cutoff is clearly shown by Fig. 4. For the same total efficiency the utilization in this cylinder is poorer with the jacket in use.

The improvement of cylinder efficiency through superheating is considerable, as is to be expected. (75 to 90 per cent. for superheated steam as compared with 68 per cent. for saturated.) The improvement in efficiency of the intermediate- and low-pressure cylinders through jacketing is somewhat less than when operating with saturated steam, as the steam is drier unjacketed than when using saturated steam.

Throughout the entire extent of the investigation the improvement in total efficiency through jacketing was offset by the non-utilization of the jacket heat in the higher stages of expansion and the poorer efficiency in the high-pressure cylinder.

A complete thermodynamic analysis of the three comparative tests was carried out for the purpose of more closely following the heat movement in the cylinder walls.

As already mentioned the amount of initial loss at the beginning of expansion, is to be considered as an indication of the cylinder utilization of the steam. When operating the engine with jacket heating, of the 375.37 B.t.u. contained in the working steam in the high-pressuer cylinder during one revolution, 54.76 B.t.u. were absorbed by the walls up to the beginning of the expansion. Without jacketing, of the 402.35 B.t.u. so contained, 47.22 were transferred to the walls. Using superheated steam, out of a heat content as before of 342.44 B.t.u., only 19.84 were absorbed by the walls in spite of the greater temperature differences; showing the evident superiority of superheating as a means for lowering the initial loss.

A large part of this wall heat returns to the steam during expansion. With jacketing of the 54.86 B.t.u. absorbed 44.05 were returned; and without jacketing of the

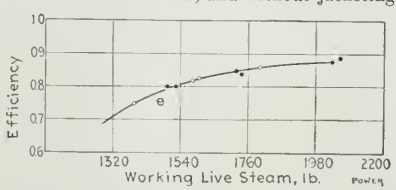


FIG. 4. HIGH-PRESSURE CYLINDER EFFICIENCY REFERRED TO TOTAL STEAM—FOR SUPERHEATED STEAM

47.22 B.t.u. absorbed 38.38 were returned. Still of this heat recovery only a very small part was converted into work in the same cylinder; about 7.9 B.t.u.

A comparison of heat-flow diagrams for the low-pressure cylinder showed a still greater difference in the heat loss at admission; 92.05 B.t.u. without jacket heating and 45.23 with. Of the 92.05 B.t.u. absorbed by the walls, 57.54 (62.5 per cent.) were returned to the steam; only 35.5 B.t.u. of which were returned to the steam during expansion and of that only an inappreciably small part (0.12 B.t.u.) was available for work.

The tests with superheated steam afforded opportunity for observing the heat loss in the piping. The temperature of the steam was taken immediately at the separately fired superheater and close to the engine. Between these points there was about 33 ft. of piping with different bends, numerous flanges and two valves, and with the exception of the flanges it was well covered with non-conducting material.

With saturated steam the heat loss was determined by separating the entrained water, but at higher velocity the separation was less. Again, with superheated steam difficulties were encountered in measuring the temperature of the steam to determine its quality as the temperature fluctuated strongly, the thermometer wells led off considerable heat and above all because superheated steam in the piping does not represent a homogeneous structure. In straight lines of piping there should be conceived existing longitudinal strata which in consequence of pipe friction have different velocities and, resultant from the outward heat flow, different temperatures. If a sudden change of direction or cross-section occurs, these strata mingle. Thus temperature measurement in a superheated steam line is of value in determining its condition only when through a whirling action of the steam at the place of measurement stratification does not exist.

The results of these tests showed that the temperature at the walls of the pipe was from 25 to 34 deg. lower than at the middle, but that moving toward the latter it rises rapidly so that the increase in temperature from a point about ½ in. from the wall to the middle of the pipe is less than 1.8 deg. The actual average temperature of the fully mixed steam would in this case lie about 3.6 deg. below the measured temperature at the middle of the pipe. In this instance the point of measurement lay just behind a bend, so that in longer straight parts of the piping a greater inequality of the steam could be expected.

Other Tests

A comprehensive view of various tests made of single-cylinder noncondensing engines using saturated steam shows an important saving of steam through jacketing. Even with large engines with an hourly steam consumption of 3000 to 6000 lb. the saving still amounts to 10 per cent.; with the smaller ones it reaches 25 per cent. or more. With single-cylinder condensing engines using saturated steam the saving within equal limits is about the same as with noncondensing engines. With very large engines having a steam consumption of over 8000 lb. per hr. the saving is unimportant; a test made while consuming 9900 lb. of steam per hour showing a saving of hardly 3 per cent.

Compound-condensing engines operated by saturated steam show a decrease in steam consumption through jacketing of 30 per cent. in smaller sizes, falling to 5 per cent. for large engines.

Compound engines with superheated steam show an improvement through jacket heating of at most 15 per cent. and from that down to none. Here it seems that for engines with a total steam consumption of 6600 lb. per hr., or 11 lb. per hp.-hr, and a heat consumption per horsepower-hour of 13,888 B.t.u. the limit of effectiveness of the jacket is reached. Again, with the smaller triple-expansion engines the saving varies between 15 per cent. and nothing, and the limit of usefulness of the jacket lies at hourly steam and heat consumptions per horsepower of, respectively, 12 lb. and 14,285 B.t.u.

Summary and Deductions

Receiver heating by means of the usual simple jacket is of no advantage: only an appreciable superheating of the steam in the receiver can be productive of improvement in the utilization of the steam, and only then to a small per cent.

Receiver drainage should be as complete as possible.

Within narrow limits cylinder jacketing results in an improved steam consumption under the following general considerations: With saturated steam the static system is to be preferred to the fluent, more so for head than for jacket heating, of which ordinarily both should be used. The saving in steam through jacketing is intimately dependent on the economy of the engine in steam consumption; the poorer this is the greater the saving. It is also greater for single-cylinder engines, for a lesser number of revolutions, and for small engines using saturated steam. For more economical engines, such as the triple-expansion type, and with superheated steam, the saving is unimportant, and is principally at the shorter cutoffs.

The limit of economy for jacket heating lies approximately at a heat consumption of 13,888 to 15,872 B.t.u. per hp.-hr.

To jacket a cylinder running on superheated steam of the usual temperature of 527 deg. or more is mostly superfluous. Moreover, a good jacket effect on superheated steam is attainable only through exceptional constructive conditions.

In the question of the economy of jacket heating the steam plant must be considered in its entirety. In plants where the water of condensation is forced back into the boilers while the exhaust steam remains unutilized, jacketing is more economical. If the exhaust is used, as for heating purposes, etc., it is often better to send all the steam through the cylinders, particularly if there is no means for utilization of the condensate.

Operated with saturated steam and at light loads it is true that the triple-expansion engine investigated showed through jacketing an improvement in steam consumption of about 5.5 per cent.; still with increasing duty this improvement diminished. At small overloads the consumption was practically the same with and without jacketing; nor was there any difference with superheated steam at normal load. Of the individual cylinder heatings, that of the low-pressure cylinder was shown to be effective.

The auxiliary test showed that with reference to friction a maintained constancy of effect was not reached before two or more hours of operation, while comparatively the temperature of the iron masses in contact with the steam was rapidly reached. Preheating or "warming up" of engines unprovided with jackets is satisfactorily accomplished by direct admission of steam to the cylinders, and by this means the inner temperatures rise materially quicker than by heating through the jackets. The fixed steam consumption per horsepower-hour appeared after three hours and during the first hour was only about 6 per cent. above normal.

In a certain Eastern school building complaint was made about the short life of the incandescent lamps furnished, many globes being found with their filaments broken and twisted to the sides of the glass. The lamps themselves, when tested in regular life racks, showed good average performances, so that a service test was finally determined upon for the purpose of studying the lamps under actual working conditions.

In twenty-six days, according to the New York Electrical Testing Laboratories, fifty-six lamps, or 29 per cent. of the total, burned out. Thirteen new lamps were then put in one of the fixtures, and after being dusted in the regular manner with a feather duster, current was turned on and four of the lamps immediately burned out. Wiping with a slightly dampened cloth was substituted for the cleaning with the feather duster, and the abnormal breakage at once ceased, indicating that the trouble was caused by the action of static charges of electricity produced by the feathers rubbing on the glass of the lamp.

The Prat System of Induced Draft

SYNOPSIS—The Prat system is distinguished from the ordinary suction system in that the blower does not handle the whole volume of gas but supplements the natural draft by induction. By this means a smaller fan is possible and better regulation is claimed.

The following is an extract translated from a pamphlet by Louis Prat, of Paris, describing the Prat system of induced draft. Although, as yet, practically unknown in this country, this system has been used extensively abroad. However, a similar system is now being put forward by an American firm—Schutte & Koerting Co., of Philadelphia. The pamphlet says in part:

The only logical solution of the mechanical draft problem is the fan blower, of which there are different methods of application, as forced, suction, and the Prat or induced system. It is wrong, as is sometimes done, to apply the term "induced" to the suction system. The Prat is the only one which acts by induction: the blower not participating directly in the suction produced.

In this method the pressure varies from point to point and where it equals that of the atmosphere it is customary to refer to it as "zero." For moderate operation the line *A* (Fig. 1) shows the pressure at the ashpit and the

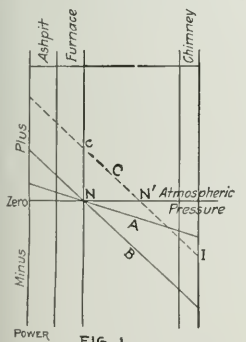


FIG. 1

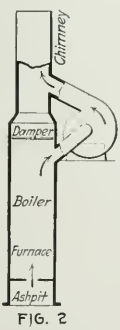


FIG. 2

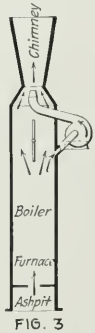


FIG. 3

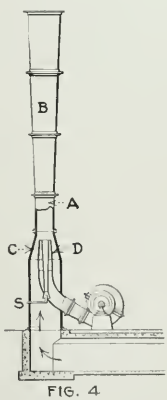


FIG. 4

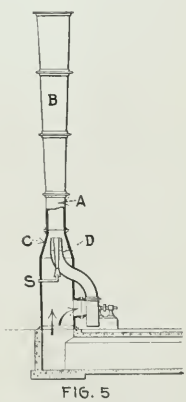


FIG. 5

sub-atmospheric, or negative, pressure at the damper. If the service be increased the discharge of the gases will be in obedience to the quadratic law and the pressures will mount considerably as indicated by the line *B*. The capacity of the chimney for negative pressure is the invariable maximum represented by the point *I*, and if, notwithstanding this, it be desired to discharge the gases at that negative pressure it will be necessary to considerably augment the positive pressure in the ashpit. This is indicated by the line *C*. But then the zero pressure will be displaced from *N* to *N'* and the furnace will be under the pressure *J*; resulting in a revulsion of smoke and, if the furnace door be opened without shutting off the air, an outburst of flame will result.

The only mode of artificial draft suited to yield entire satisfaction for all conditions of combustion, no matter how forced, is that based on suction and with which method there is practically no limit to the negative pressure furnished at the chimney. But a distinction should be made here between the ordinary suction draft and the Prat system of induced draft.

With the direct suction draft of Fig. 2, the damper should always be closed, otherwise the fan would operate without useful effect. It is thus necessary to pass the total volume of the gases through the fan, hence an enormous bulk for the latter. If, to cut down the cost, the size of the fan be restricted, which is compulsory in practice, the resistance is very much increased. Not only is the benefit of natural draft thus lost but the total resistance of the circuit is increased and the work of the fan is greatly enhanced: first, because of this added resistance and second, because of its operating through too large an orifice.

The Prat induced draft system differs fundamentally from the foregoing suction system. The damper, no longer necessary, is always open; the chimney is freely divergent and, the resistance being but little affected, a full utilization of the natural draft is obtained gratuitously.

In addition only a very small fraction of the volume of the gases is passed through the fan to give it an adequate live pressure—a twofold reason for a fan of small bulk. This live pressure is used in the manner of the impulse jet of an ejector to create the necessary negative pressure for the induction of the gases; whence the name "pressure transformer" given to the Prat chimney.

In effect the power here furnished is nothing more than a simple acceleration of the natural draft, automatically variable within certain limits, and the fan acting on the reduced orifice, can be chosen to suit the maximum service.

Concerning the limitations of the direct and suction systems, of the former those styled compensated, balanced, etc., are in fact pressure drafts and include the automatic damper regulator. These systems have as their guiding principle the automatic maintenance in the furnace of a pressure equal to that of the atmosphere, thus reducing the leakage of air into the furnace. In reality the furnace is not at zero pressure but under a slight negative pressure which increases in a negative direction up to the damper. The richer the coal the less it is possible to approach the zero pressure in the furnace on account of the smoke action at the time of firing.

The advantage of the diminution of air entrance is acquired at the cost of complications including an auto-

matic regulator to control the speed of the fan and an automatic regulator to control the draft.

As to the suction system it avoids the complications inherent in the forced or balanced systems of subgrate air supply. The installation is simple, the losses due to elbows are smaller and the destruction of the grates disappears; but, as seen, it means fans of abnormal dimensions. For a battery of large boilers, as in a central station, it would be practically impossible, and to avoid this difficulty a fan is used too small for the opening through which it must operate.

The general arrangement of the induced system designated as a "pressure transformer" (Fig. 4) includes essentially a metal plate stack comparable to an ejector of which *C* is the converging portion, *A* the chamber and *B* the diffuser. The negative pressure inducing the flow of the gases is created by a fluid impulser furnished by a fan blower and injected into the chamber by the nozzle *D*. In case of a stoppage of the fan the impulse is produced by an emergency steam ejector *S*.

This fluid impulser can be either the cold air taken from the atmosphere or the hot gases taken from the flues. With the former method, called "outer circuit," (Fig. 4) the fan is entirely outside of the current of gases and consequently under the best conditions for its maintenance and preservation. In all cases the addition of the cold air lowers the temperature of the gases and the degree of utilization of the natural draft is diminished in proportion to the cooling.

With the latter method, known as the "inner circuit" (Fig. 5) the fan runs in the heated gases as in the ordinary suction draft; but the injection of cold air is done away with and the power needed becomes extremely small.

Mechanical draft has often been criticized as having a lesser degree of certainty than chimney draft, as failure of its operating source or its injury will cause the fan to stop and almost entirely suppress the draft. The only safety against such a contingency is an auxiliary or emergency fan; meaning a considerable increase in the first cost of installation and in the space occupied.

In the Prat system the emergency provision is represented by a steam jet blower as shown in Figs. 4 and 5. Contrary to the case of ejectors used for blowing beneath the grates it is here permissible to select such dimensions as will promote a satisfactory utilization of the steam, of which the consumption for this auxiliary draft is by no means great. Furthermore, the operation of this ejector in conjunction with that of the fan permits doubling the draft, a matter of perhaps great utility at a time of unusual demand for steam.

It often happens with existing plants that the desire is to increase the draft of the present chimney. The Prat system is especially adapted to such cases, its small bulk permitting its being placed inside of the chimney, and besides there is retained all the benefits of the natural draft due to the height of the chimney.

In conclusion the pamphlet states that the advantages of mechanical draft are less and less disputed as its application becomes more widespread. The principal points in its favor are elasticity of production, economical combustion, rendered easy by the facility of regulation of the exact amount of air in relation to the combustible used; and variability of the pressure produced, independent of atmospheric changes and boiler operation.

Coon Creek Rapids Development

Active construction of the water-power development known as Coon Creek Rapids, 11 miles northeast of Minneapolis, has been started by H. M. Byllesby & Co. It will have an initial capacity of 12,000 hp. and will furnish additional power to the Minneapolis and St. Paul properties.

The dam is being built under a permit granted by Act of Congress. This act requires that the construction and operation of the dam are to be carried out under the supervision of government engineers. The permit is for a period of 50 years.

The dam will consist of earth embankment with core walls 600 ft. long, a power house and retaining section 470 ft. long, including sluice gates, log chute and fishway; and a spillway section 1000 ft. long, making the total length of the structure 2070 ft. This work will involve 20,000 cu.ft. of earth embankment and approximately 45,000 cu.yd. of steel-reinforced concrete.

To secure a suitable and safe foundation, there will be used in the construction approximately 8000 round wooden piles, driven down to firm foundation. There will also be used 1000 tons of interlocking sheet-steel piling in lieu of a cutoff wall for retention of water in the reservoir and to prevent under-cutting of the dam.

For the greatest possible head at all stages of river flow and to prevent excessive flood heights, Tainter gates will regulate the water-level in the reservoir. Twenty-eight of these steel gates, each 12,000 lb. in weight and 33 ft. long, will be erected between reinforced-concrete piers built on the spillway portion of the dam. The fishway, designed in accordance with government requirements, will provide for the free passage of fish up and down stream, and the log sluice will have a convenient means for passing logs by the dam.

The first installation will provide for 12,000 hp. with the most efficient type of waterwheel units driving enormous electrical generators, which will transmit current to Minneapolis at 13,300 volts, thus tying in directly, without transformers, with the general distribution system of the Minneapolis General Electric Co. at the Riverside steam plant. The transmission line for conveying the electric current to Minneapolis will be erected part of the way on private right-of-way and along the right-of-way of the recently completed tracks of the Minneapolis & Northern R.R.

A construction camp has been established at Coon Creek Rapids, and a camp for 400 men provided, to be increased later to accommodate 800 to 1000 men during the spring and summer months. The camp is equipped with its own water-supply and sewage system. Following modern methods, a hospital, with a surgeon, trained nurses and attendants, will be in operation during the construction. All matters in relation to water supply, sanitation and policing of the camp will be handled in the same way as they would be handled for a modern city. The camp will be electrically lighted throughout, current being supplied for this lighting by the Minneapolis General Electric Co. Electric current will also be used for driving a considerable portion of the construction plant.

During the construction of the dam there will be distributed for labor and commissary supplies, approximately $600,000. The housing and feeding of the construction men are in themselves an enormous undertaking.

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Field-magnet Cores

Generally the polar end of a field-magnet core—that end which is nearest the armature—is enlarged, as represented in Fig. 140. The object is to reduce the magnetic force required to drive the flux across the airgap. Magnet cores are usually of steel and to economize in material the cross-section of the core is made of such an area that the magnetic density in the core is about 90,000 to 100,000 lines per sq.in. If the polar end of the core were left unenlarged, as in Fig. 141, the density in the airgap would be so high that an excessive magnetizing force would be required.

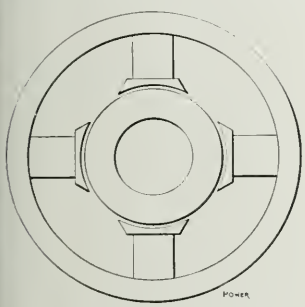


Fig. 140. Modern Four-pole Field Magnet

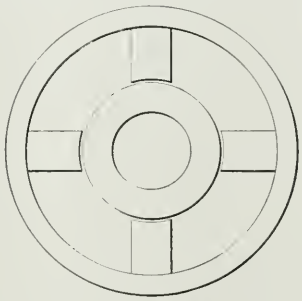


Fig. 141. Field Magnet without Polar Extensions; High Airgap Density

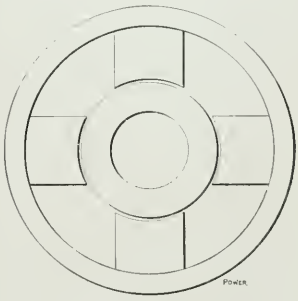


Fig. 142. Field Magnet without Polar Extensions; Normal Airgap Density

For example, with the construction shown in Fig. 141 and a magnetic density in the core of 90,000 lines per sq.in. of cross-section, the density in the airgap would be about 80,000 lines per sq.in. With this density, if the airgap were ¼ in. long, it would require

$$80{,}000 \times 0.3133 \times \tfrac{1}{4} = 6266$$

ampere-turns to force the flux across the airgap. With polar extensions, as in Fig. 140, the area of the airgap could be increased enough to bring the magnetic density down to about 50,000; at that density the magnetizing force required to drive the flux across would be only five-eighths of 6266, or 3817 ampere-turns.

It is possible, without using polar extensions, to keep the density in the airgap down to a reasonable figure by making the magnet cores larger than necessary, as illustrated in Fig. 142, where the airgap area is the same as in Fig. 140. This construction is used in some small machines built with cast-iron magnets, but it is not used in machines of larger size because of the waste of material and increased weight entailed. In some cases the weight of the magnet has been kept down by slotting the core as indicated in Fig. 143, but even with this arrangement an excessive quantity of copper must be used in the field winding because of the larger girth of the core as compared with the type illustrated in Fig. 140. Moreover, this form of core usually results in an increase in the diameter of the yoke ring, because the magnet coil cannot be made as thick (at right angles with the length of the core) as when the smaller core is used and it must therefore be made longer to get enough wire in it to prevent overheating.

The slotted form of magnet core is advantageous, however, in preventing great distortion of the airgap flux by armature reaction,* and it has been used successfully for that purpose by a few builders. When so used, however, it is not necessary to make the core the full width of the airgap, as in Fig. 143; the slot is made very narrow and the core is made with polar extensions somewhat as in Fig. 140, except in one instance where only one extension is used, as shown in Fig. 144. This is a very special form of construction, however, and scarcely comes within the scope of general elementary discussion.

Core Cross-sections

Magnet cores are made in several forms as to cross-section, and even though the student may never have occasion to design or build a dynamo, the influence of different forms and the reasons for using them are of practical interest.

On account of the cost of copper, the field-magnet core is usually made with a view to economizing in the use of magnet wire, even though some increase in the cost of the core or frame may be entailed. The form of core cross-section which theoretically should be used to obtain the greatest economy in wire is round; the form which comes next in line is octagonal with rounded corners; next oblong with rounded ends, next square, and so on.

Fig. 145 shows the relative lengths of wire necessary to reach once around different practical forms of core, all of the same cross-sectional area. The distances around the

*The effect of armature reaction upon the airgap flux was briefly referred to in one of last year's Primer lessons. It will be explained fully in a future lesson.

outside of the cores are expressed in percentages to afford easy comparison. The circle is put at 100 per cent. because it has the smallest girth. The figures indicate that a square core requires about one-eighth more wire to "surround" it than a circular one, and a 2-to-1 rectangular core nearly one-fifth more. But this does not mean that the quantity of wire required in the complete coil is one-eighth and one-fifth greater, respectively. When the girth of the coil is large, its length parallel with the core can be made smaller, in most cases. This point will be discussed fully in a later article on windings.

The shape of a magnet-core cross-section is largely determined by the material of which the core is made. When cast iron is used the cross-sectional area must be nearly twice as great as when steel is used, because the magnetic density in cast iron cannot be carried much above one-half of the density in steel, which requires about the same excitation in the field winding. For this reason it is important to make the girth as small as possible for a given cross-section. Therefore, a cast-iron core should logically be made with a circular cross-section if possible. When steel is used, the form of the cross-section is not so important so far as economy of field-magnet wire is concerned and the shape is determined more by the method of constructing the magnet than anything else.

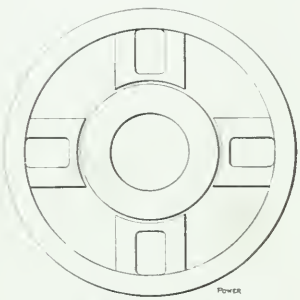


Fig. 143. Magnet Cores Slotted to Reduce Weight

Fig. 144. Core Slotted to Prevent Field Distortion

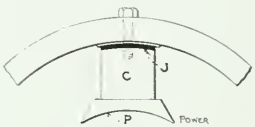


Fig. 146. Magnet Core Bolted to Yoke

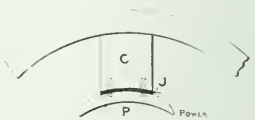


Fig. 147. Magnet Core Integral with Yoke

Fig. 148. Laminated Magnet Core

the piece P is usually termed the "poleshoe." The joint J between it and the core generally is a circular arc, because it is easier to bore the ends of the cores to a circle than to finish them flat. The thickness of the curved line J, indicating the joint, is exaggerated purposely, to emphasize the location of the joint.

Often the magnet cores are built up of thin sheets of steel or iron ("laminated") of a form about like that shown in Fig. 148, the thin sheets being held between two heavy cheek plates as indicated at the right. The chief object in using this construction is to avoid inducing eddy currents in the face of the pole—exactly the same reason for which armature cores are laminated. Reference to the lesson on this subject* is advisable. Another reason for using laminated magnet cores is that thin pieces of iron or steel become magnetized and demagnetized more quickly than thick pieces, and a laminated core will therefore respond to changes in field excitation more quickly than a solid core will. Some small machines are built with the entire field magnet laminated. The reason, however, is not a technical one; the main object is economy in manufacture.

When the yoke ring of a machine is of cast iron and the magnet cores of steel or wrought iron, the form of construction shown by Fig. 146 is not advisable. The flux density in the magnet core is much higher, as a

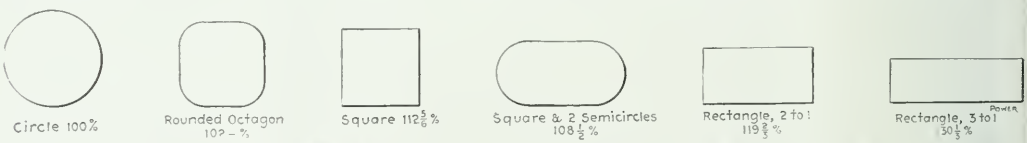


Fig. 145. Relative Girths of Magnet Cores Having Equal Cross-sections of Different Proportions

Figs. 146 and 147 illustrate the two methods of "making up" field magnets which are most used. On account of the usual necessity of enlarging the end of the core nearest the armature, the core must be made removable from the yoke to get the magnet coil on it, or else the enlarged end must be removable from the main part of the core. Fig. 146 illustrates the former construction, the heavy line J indicating the joint between the core and the yoke; the enlarged portion P is made in one piece with the core proper. Fig. 147 illustrates the other construction, in which the enlarged part P is attached to the core C along the line J. With this construction rule, than cast iron can be worked economically, and the excitation required to force the flux into the cast-iron face at the joint J would be too great to be practical. In such cases, to avoid excessive densities in the cast iron at and near the joint, the method of construction most used is to cast the yoke around the ends of the magnet cores. Fig. 149 illustrates such construction. The "heel" of the magnet core is grooved and the cast iron flows into the grooves and holds the core tightly in place. The grooving also serves to increase the area of contact between the cast iron and the steel and thereby reduce the

*Power for Apr. 19, 1910.

resistance to the passage of magnetic flux between the two metals. (This magnetic resistance is called "reluctance".)

Casting the yoke metal around the ends of the magnet cores is not easily done satisfactorily. The flow of the molten iron almost invariably shifts the magnet core in the sand mold, and sometimes the hot iron is chilled by the cooler steel to such a degree as to cause it to shrink and leave an imperfect contact. To avoid this method of construction and still retain the iron yoke and steel cores, machines have been built on the principles illustrated by Figs. 150 and 151.

Fig. 150 shows a wrought-iron or steel plate S inserted between the heel of the core and the yoke. This

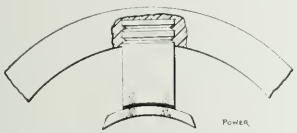


FIG. 149. IRON YOKE CAST AROUND STEEL MAGNET CORE

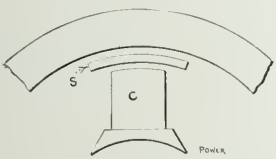


FIG. 150. INSERTED FLUX-SPREADING PLATE

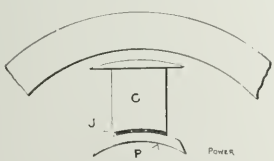


FIG. 151. CORE WITH EXTENDED HEEL AND REMOVABLE POLESHOE

serves to give the flux a path of low reluctance through which to "spread" in its passage between the core and the yoke. The construction in Fig. 151 does the same thing, but the spreading plate is in one piece with the magnet core, and the core is therefore provided with a removable poleshoe. Both of these methods have proved rather expensive in manufacture and for that reason neither has come into general use.

Switchboard Losses

The article in the Feb. 25 issue on "Improving the Conductivity of Joints," leads me to write on a matter very similar in character.

There are apparently few engineers or designers of power plants, particularly among the small ones, who consider the value of high-grade instruments, especially with reference to the use of voltmeters requiring a very small current; ammeters whose moving coils are operated by a very small current, or whose shunts have a very low resistance; switches of sufficient capacity in the blades as well as sufficient contact area in joints and jaws to give a low drop; and circuit-breakers designed under similar conditions.

In a power plant having a large number of these devices, the loss due to the foregoing causes can amount to a very large sum of money, far more than paying the difference in cost between good and bad installation. This condition of affairs is usually far more serious than the loss of power over joints. For instance, if a voltmeter on a 550-volt circuit, requires 0.2 amp. to give it full scale reading and it is in use continuously, the loss per year, based on power at 2c. per kw.-hr., would be $19.44; whereas with a voltmeter requiring only 0.01 amp., the loss would be 97.2c., showing a yearly loss of the former over the latter of $18.46, or representing an investment value of $307.40 based on interest at 6 per cent. This shows very conclusively that the difference in the cost of the two instruments would be more than made up by the power saved.

Consider a shunt of 10,000 amp., having a drop of 50 millivolts, and another one of 80 millivolts. The loss in the first case with power at 1c. per kw.-hr. would amount to $43.80. In the second case it would amount to $70.08, a difference of $26.28, representing an investment value of $438. This, of course, is on the basis of the instruments being operated at full capacity continously. If the average load is one-half this, the investment value would represent $219, which would more than pay the difference in the cost of the two types of instrument and shunt.

It is not uncommon for power plants, having increased their capacity, to changes the capacity of the ammeters by inserting additional resistance in the moving coil circuits, in order to increase the range of the shunt. In one plant where this was done, the range was changed from 60 to 122 millivolts. The loss with power at 1c. per kw.-hr. was $160.80 per year, representing an investment cost of $2680. The cost of replacing the shunt would not have been more than $300, including labor, showing a saving of $142.80 per year.

The same method of figuring might be carried through switches and circuit-breakers to advantage. Of course, the value of doing this depends largely upon the cost of power.

The same condition might readily occur in connection with wiring. It is frequently possible to lay out wiring where the drop may not be sufficient to cause any difficulty in the operation of lamps or motors; but this is not the only thing to be looked out for. If the loss over these wires is figured, it will many times be found advisable to install more wire than enough to allow operating voltage, as the interest on the increased cost of the wire will be less than the cost of the power saved by the smaller wire.

HENRY D. JACKSON.

Boston, Mass.

A 20,000-kw., 13,200-volt, 60-cycle Westinghouse turbo-generator is to be installed at the Marion plant of the Public Service Co. of New Jersey. A still larger unit is being built by the same manufacturers for the United Electric Light & Power Co. of New York. This is a 22,200-kw., 11,000-volt, 25-cycle machine.

GAS POWER DEPARTMENT

Producer Gas in Heating Furnaces

By Everard Brown

One of the principal advantages in the use of natural or artificial gas is that both can be burned in either regenerative or recuperative furnaces. This permits a furnace being so designed as to obtain comparatively low temperatures of the waste gases.

Natural gas, in locations where nature has provided it in sufficient quantities for manufacturing purposes, is, of course, preferable to the artificial or producer gas because it can be transported long distances, worked under pressure and, being cleaner, can be burned much more efficiently. Its use also eliminates all of the labor costs and troubles incident to the manufacture of producer gas, although the importance of this factor depends entirely upon the comparison between the cost of the one and the cost of manufacture of the other. As for burning coal either regeneratively or recuperatively, experience has demonstrated that it cannot be done successfully, at least with the present-day equipment. The chief obstacle in the use of coal for this purpose is that the checker-work in the regenerative chambers and the flues soon clog with heat. Another difficulty is that the grate bars burn out quickly, particularly with the introduction of a hot blast.

Considerable heat is lost in the transformation of coal into gas, nevertheless this loss is amply compensated for by the use of regenerative chambers as compared with burning coal direct in an ordinary furnace. For instance, assume that a pound of coal contains 13,500 B.t.u. In transforming this coal into producer gas there is loss of about 20 per cent. in gasifying, heat carried away in the ashes, radiation losses, etc. There is available, therefore, about 10,300 B.t.u. for heating purposes. But, owing to radiation and other losses in the furnace consuming the gas, this available amount is further reduced to about 9200 effective heat units. In burning this pound of coal direct in a furnace there would be practically the same losses that occur in the gasifying process, so that by the direct-firing method there would be 1100 heat units—the difference between 10,300 and 9200—more put into the furnace than by the other method. To offset this difference in favor of the coal, however, it must be remembered that the gas can be well and thoroughly mixed with air, thus resulting in more perfect combustion. The net result is, therefore, that the two methods are very evenly balanced as far as the actual input of heat into the furnace is concerned.

It is apparent, then, that any great advantage to be found in the use of producer gas must be looked for in the furnace itself. In the case of a regenerative furnace, general practice has shown that approximately 20 to 25 per cent. of the original heat value in the coal gasified goes into the material to be heated in the furnace. On the other hand, where the coal is fired direct into an ordinary furnace which, consequently, cannot have regenerators, the stack temperatures are exceedingly high so that the efficiency of the furnace is generally not more than 10 per cent. That is, it will require about 2 lb. of coal fired direct to attain the same results as with one pound consumed as gas. If coal is worth $1.50 per ton and the expense of firing it directly into the furnace is equal to that of making producer gas and assumed to be 25c. per ton, then the producer-gas method of firing would result in a net saving over the direct-firing method of $1.75 per every ton consumed.

In this connection, however, it must be remembered that the use of producer gas in preference to the direct firing of coal will show an appreciable advantage and gain in economy only in such furnaces as will give relatively low stack temperatures. For example, in a long, continuous heating furnace where a stack temperature in the neighborhood of 600 deg. can be had, the economy in using producer gas is rather doubtful. It is also well known that for firing boilers producer gas does not give nearly as high efficiencies as are obtained with coal.

One of the greatest factors in the successful operation of a gas-producer plant is the proper kind of equipment. For example; a water-sealed producer with a revolving grate will gasify probably 10 per cent. more coal per square foot of grate area than that with a stationary grate; due largely to the time lost in suspending operations every time the stationary grate is cleaned. Furthermore, there is some gain in the water seal, because the heat in the ashes, which would otherwise be dissipated, generates some steam, which helps to keep the fire in a better condition. There appears to be, however, some difference of opinion as to the capacity of the water-sealed producer compared with the ordinary grate type.

The cost of repairs and maintenance incident to the manufacture and burning of producer gas should not be a serious consideration. Ordinarily, this item should be no higher than for the ordinary coal-fired furnace, as the temperatures in the producer are rarely as high as in a furnace.

The question of coal, however, is quite important. The best results are usually obtained with a coal containing a high percentage of volatile matter, but low in ash and of such a composition that it will not fuse and clinker badly. The best depths for the fuel bed are given from 2½ to 7 ft.

All pipes, flues and connections should be amply large. In the first place, small ones quickly choke with soot, and a higher pressure is required to force the gas through them. Secondly, with ample sized pipes and flues there is proportionately less radiation. It might be argued that the condensation of the gas would be reduced by using smaller flues and pipes because of the higher velocity of the gas through them, yet, on the other hand, the temperature losses would be proportionately greater, which would probably cause even greater condensation.

About the maximum distance that producer gas can be successfully carried is 400 ft. The question then arises whether it is better to have the producers in groups when

serving several detached furnaces or to have single producers adjoining the furnaces. In the first case coal- and ash-handling machinery can be installed which will lower the labor cost considerably. It is also true that a better and more uniform gas is obtained. The disadvantages of such an arrangement, on the other hand, are radiation losses, leaks that are more apt to develop in a long line than a short one, and the burning of the gas in the producers. A little figuring, however, will show that it requires a much greater loss, due to radiation, leaks, etc., than occurs in ordinary practice to offset the gain in labor saving by grouping the units.

As to the amount of steam required to operate gas producers, there is but little authentic data and no general rule can be given. The character of the coal used has much to do with this question as more steam is needed for coal which clinkers badly than for that which does not. The size of the gas mains and the capacity at which the producers are worked are also determining factors. In a general way, however, it may be stated that under ordinary conditions not more than from 2 to 5 per cent. of the heat units in the coal are needed to generate sufficient steam. As some of this heat is returned to the producer, the actual loss is less. If possible, the steam used should be superheated to prevent condensation and moisture for, if wet steam is introduced, a chilling action might result from reëvaporation. It has also been found that a hot blast gives better results than a cold one. The pressure at which a producer is blown usually ranges from 30 to 40 lb. per sq.in.

One of the worst troubles in connection with gas-producer operation is the nonuniformity of the gas. Very often this is the result of poor attention and could be remedied by a little extra watchfulness to see that the fires are kept level and free from holes, that the coal is fed at proper intervals, that the necessary poking is done, and that the proper amount of steam is introduced, etc. There also seems to be universal trouble in securing good men for this class of work which really requires as much, if not more, skill than firing boilers.

To eliminate as many of the troubles as possible resulting from the improper handling of producers, there are now several types on the market having more or less automatic attachments. However, an expert fireman can probably get better results than can be obtained through the use of any automatic device. Experiments with water-cooled, automatic pokers and automatic-feeding devices have brought about considerable improvement, as has also the principle of rotating either the whole or a part of the producer itself. The charging of coal through chutes from overhead bins, on the contrary, is an improvement of doubtful value as this practice allows the coal to come down with a rush, making it difficult to properly regulate the quantity charged. This is particularly true with run-of-mine coal. If the coal were crushed to a uniform size and the slack screened out, the results would no doubt be much better in this respect.

⁂

A 15,000-hp. Pelton wheel, believed to be the largest unit of the type in Europe, is being installed in the Löntsch hydro-electric power station on the Klonthalersee near Glarus. The present installation consists of six 6500-hp. Pelton wheels, directly connected to their respective generators. The new unit will increase the capacity of the station from 39,000 to 54,000 hp., making it the largest in Switzerland. The new turbine will be constructed by Theodor Bell & Co., of Kriens, and the electrical equipment by Brown, Boveri & Co., of Baden.—"Engineering Record."

Largest Diesel Engines in This Country

Phelps, Dodge & Co., New York, have recently purchased two 1000-hp., two-stroke-cycle, four-cylinder Carels-Diesel engines for installation in one of their Arizona mining properties.

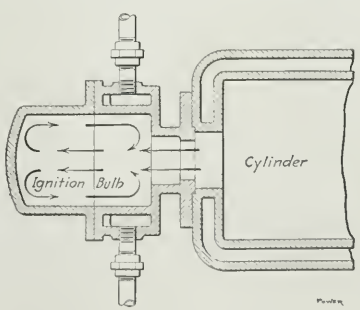
Special interest centers about these engines in that they are the largest of the Diesel type to be erected in this country. They will be direct-connected to 60-cycle alternators to operate in parallel, and are guaranteed to deliver 1000 hp. at an elevation of 6500 ft., using not more than 0.48 lb. of oil per b.hp.-hr. A number of similar engines are now in use for central-station service in Brussels, Paris and Bucharest.

CORRESPONDENCE

Igniters for Oil Engines

Oscar P. Ostergren, in his article on "Classification of Oil Engines," Feb. 11 issue, referring to the Hornsby type of bulb igniters for oil engines, says: "The principle represented in Figs. 4 and 5 is extremely simple." He follows this statement by a very brief description of the action of such an igniter. This apparatus, although very simple in construction, seems to me to be very complicated in principle.

For proper ignition, it is necessary to bring a correctly proportioned mixture in contact with the walls of the bulb for sufficient time and at the right time to raise a part of it to the ignition temperature. The bulb is heated by a torch for starting and by the heat of combustion of the oil while the engine is running. The oil is injected into the bulb during the latter part of the suction stroke in the form of a solid stream which impinges against the side of the hot bulb. Some of it is vaporized immediately, and some of it later by the heat



Section through Ignition Bulb

of the bulb. The bulb now contains oil vapor (and possibly some unvaporized oil) and products of combustion from the previous explosion. Combustion does not occur at this point because there is no air to support it. As the compression stroke starts, air is forced from the cylinder into the bulb. The manner in which this air enters causes currents to be set up in the mixture in the direction shown by the arrows in the sketch. Due to the variation of the piston velocity these currents are

slow moving at the beginning of the compression stroke, rapid at the middle of the stroke, and slow again at the end. Toward the middle of the stroke there may be enough air in the bulb to make an explosive mixture, but these currents are then moving with such a high velocity that no one portion of the mixture comes in contact with the hot walls of the bulb long enough to be heated to the ignition temperature. As the piston approaches the end of the stroke, the circulation slows down, and when the combined heating actions of the hot bulb and compression bring any part of the mixture to the ignition temperature, an explosion occurs. A portion of the bulb is covered by a jacket space, and, therefore, by varying the cooling-water temperature (or when designing, the amount of jacket space at this point) it is possible to vary the temperature of the bulb and consequently the timing of ignition. Thus with proper care in operation and design, the "danger of premature ignition" should be very small.

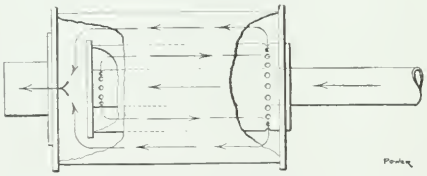
WILLIAM J. DEMOREST.

New York City.

Exhaust Muffler

The temporary exhaust pipe from the first big gas engine installed in the power house of the Ford Motor Co., at Detroit, was a simple straight run of 14-in. pipe extending vertically along the outside wall of the power house. While the noise from the exhaust was not excessive, it was found to be somewhat objectionable, and a muffler was fitted to the end of this pipe, built as shown in the accompanying sketch.

This muffler is simply a large size of exactly the same



FORD MUFFLER

type as is used on the Ford cars and was found to be extremely efficient. The noise from the exhaust is scarcely audible on the ground just outside the power house.

This muffler can easily be built of various sizes of ordinary pipe. The labor cost is low and the result is extremely satisfactory.

L. L. BREWSTER.

New York City.

Test of Producer Plant

Referring to the article under the above caption in the Feb. 4 issue, I recognize the plant in question as the one in which I was night engineer for over a year. I was disappointed at not getting a fuller report of the test and would ask Mr. Brewster to state more of the operating conditions. What are the average and the peak loads? How much of the normal capacity of the three 100-kv.-a. units is utilized? Also, how much power is supplied to the factory by the central station and how much does this cost? Furthermore, he does not state the cost per kilowatt-hour, the cost of maintenance, nor why the owners wanted the test made.

Mr. Brewster says there was no tar found in the gas. Can he tell us what that black, gummy substance is that plugs up the rotary exhaust scrubbers, heavily coats the inlet valves and manifold and rolls up in the form of a ball in the ends of the inlet manifold? I should also like to know whether he discovered the cause of the rapid corrosion (or whatever it is) of the valves, especially the inlet valves, which requires them to be cleaned and ground about every two weeks.

I have some very interesting data on this plant, which would indicate why the owners wanted a test made and also why the central station frequently gets in where it has no business to be, but I would like to hear from the author of the article first.

An average of 3.08 lb. of fuel per kw.-hr. looks rather high for a "thoroughly modern plant" operated by a "crew well above the average." Our plant is not nearly so large nor so thoroughly modern and our standby is 109 hr. of the 168 hr. per week; yet, our coal consumption (Lykens Valley pea) is slightly less than 2 lb. per kw.-hr.

L. L. DOUTHAT.

Jersey City, N. J.

Steam in Producer Room

While in charge of several pressure gas producers, considerable trouble was experienced with steam arising from the surface of the water in the top of the producer. One very cold morning, when entering the producer room, I could hardly see the men because of steam, which, together with the gas coming from the poke holes while working the fuel bed, made it very hard for the men to keep from being overcome.

I conceived the idea that if a film of oil could be kept on the surface of this water, the trouble might be lessened. Therefore, I cut a piece of tin and formed it around the overflow in such a manner that the water going to the overflow would have to pass under this tin while the oil would not. By putting about a quart of oil on the top of each producer, the steam at once stopped, and, in many places, the oil was so thin that I could see the producer top through it.

M. W. EASTMAN.

Cambridge, Mass.

What Caused the Pound?

In answer to Mr. Abel's inquiry in the Jan. 28 issue, I would say that I have encountered the same trouble in multi-cylinder vertical engines, and have always found that the pound was caused by some of the other cylinders not performing their share of the work, thereby putting an overload on the cylinder which was operating all right. This causes excessive heat in that particular cylinder and the igniter becomes so hot that it holds fire and causes early ignition, which cannot be regulated by the timing device.

The trouble may be due to leaky valves, but most generally will be found in the igniters.

H. H. DELBERT.

Titusville, Penn.

HEATING AND VENTILATION

Room Temperature and Radiating Surface*

A consideration which has not been scientifically studied, is the question of the proper temperature at which the air in a room should be maintained. In the United States, it is customary to assume that a temperature of 68 to 70 deg. F. is most suitable for rooms in which persons are not actively engaged. In Germany, for similar rooms, a temperature of 65 to 68 deg. F. would be regarded as sufficient, while in England a room is considered properly heated when the temperature is 55 to 60 deg. F. In one of the great English universities, classes are often held in rooms when the temperature does not exceed 55 deg. F., but, under the same conditions, in the United States, the class would be dismissed. What is the reason for this difference of temperature required by different nationalities? Is it due to personal peculiarity, custom or climatic conditions? Possibly the proper temperature in one locality may be different from that of another. The outside temperature may have much to do with the temperature required indoors, as it is a well known fact that people living in countries where the temperature is extremely low usually require higher indoor temperature.

Many rules have been proposed for determining the proper amount of radiation to be placed in a room, and practically all of these rules are based on the assumption that the heat so applied to a room shall equal the heat lost from the walls and the windows. There are other conditions entering into the determination of the proper amount of radiation that should be placed in a room which are often allowed for by adding on percentages, but the percentages allowed in most cases are not based on any scientific hypothesis. For example, the intermittent heating of a room will affect the amount of heating surface to be placed in the room and the amount added will depend upon how quickly it is desired to heat the room after it has been cooled.

Where buildings are intermittently heated, or are of heavy construction, far more heat is required to warm the walls of the building in a reasonable length of time than to take care of the heat transmission. Again, most of the rules used in determining the amount of radiation to heat a given sized room assume that the room must be heated at a temperature corresponding to the lowest temperature which exists outdoors for any length of time. Theoretically, such a proposition is absurd, as, obviously, if just enough heat was supplied to provide for the heat lost from the room and the conditions all remained constant, it would require an infinite length of time to warm the room. Fortunately, the heating engineer figures the radiation to heat the building at a much lower temperature than the average; and during the warm days heat is stored in the walls from the excess given off by the heating plant and absorbed by the sun. During the very cold days this heat is given up and reduces the heat loss from the building, serving to correct the errors in the engineer's calculation. In many of the great cathedrals of Europe no heating system is provided and these buildings are never uncomfortable, owing to the heat stored in the building structure during the summer months and returned to the air during the colder months. A good example of the use of heat stored in a building comes from Germany.

Recently a state dinner was to be given in a castle which had no heating system. The engineers were asked to heat the building for the dinner; but it was specified that no portion of the heating system was to be visible in the room. The result was accomplished by means of stored heat. For a number of days previous to the dinner, the floor of the dining room was covered with steam pipes and these pipes were kept hot by means of a temporary boiler. The day before the dinner all the pipes were removed and the stored heat in the walls maintained the room in a perfectly comfortable condition for a number of days, although the outside temperature was well below the freezing point.

None of the rules for heating take these conditions into consideration. It is quite possible that it would be better in buildings of heavy construction to base the necessary amount of heat to be supplied not upon the minimum external temperature, but, rather, upon the average external temperature. Most heating engineers allow a large margin of safety which covers their ignorance of the conditions entering into the problem.

*Excerpt from Prof. J. R. Allen's presidential address to the American Society of Heating and Ventilating Engineers.

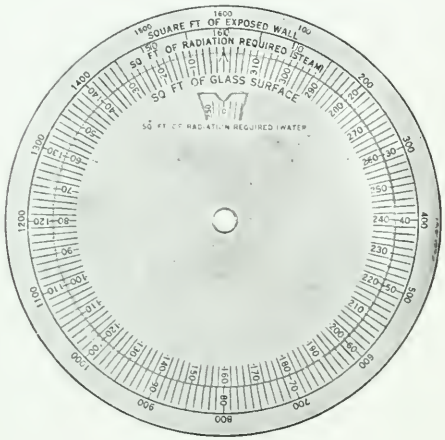
Calculator for Residence Heating

A convenient calculator for computing the square feet of radiation for steam or gravity hot-water heating in a residence has been copyrighted and placed on the market by the Novelty Calculator Co., of Watertown, N. Y. It is arranged in convenient form on a celluloid card, 3x4½ in., together with full directions for operating and an example to illustrate the process. The arrangement of the calculator is shown in the accompanying illustration. By placing the square feet of glass surface opposite the square feet of exposed wall surface, the square feet of radiation for steam will be found opposite the arrow on the dial; or, for hot water, opposite the pointer in the window. The calculator is based on an outside temperature of zero and a room temperature of 70 deg. F., a difference of 70 deg. If the temperature is lower than zero outside, the proper amount of radiation may be computed by means of a second calculator on the opposite side.

In laying out the calculator, the heat loss through the walls was taken as 0.341 B.t.u. per sq.ft. per hr. per deg. difference, or 21 B.t.u. for 70 deg. difference, and the heat loss through a square foot of glass as 1.71 B.t.u. per hr. per deg. difference, or 120 B.t.u. for 70 deg. The

ratio of glass to wall surface appears to be 1 to 10. With steam at 2 lb. pressure, the radiation per square foot was taken as 240 B.t.u. per hr., and for hot water, with a temperature of 180 deg. at the boiler, as 180 B.t.u. per hr. The coefficients of heat loss through the walls and glass surface were purposely made high to allow for air change through leaky doors and windows and irregularities in the heating system, which are sometimes necessary and tend to reduce the efficiency of residence heating.

When the room is of such size as to overrun the limits of the calculator, the arrow will not indicate enough



Face of Calculator

radiation. By observing the following rules this difficulty may be avoided.

Reading clockwise, if the arrow is between the determined wall surface and 160 sq.ft. of steam radiation, the results are as shown.

Reading anti-clockwise, if the arrow is between the wall surface and 160 sq.ft. of steam radiation, add 166 to the result shown.

*

Operating Cost of Indirect Heating Systems*

By Frank L. Busey and Willis H. Carrier

The object of this paper is to show that there is a definite relation between the cost of power and the cost of the apparatus, and to determine what ratio between these two factors will insure the lowest practical yearly outlay to cover the cost of power, as well as an allowance on the cost of the installation to care for interest and depreciation. It will be found there are two power requirements to be met at the fan of a hot-blast heating system, one due to maintaining the required velocity head and the other depending on the loss in pressure due to the frictional resistance of the system. The first item is fixed when the velocities through the system are decided upon. The second item of requirement is due to two sources—the resistance through the heater and the friction through the piping and ducts of the distributing system. These are two separate sources of pressure loss, and either one may be studied independently of the other and changes made, as one does not necessarily affect the other. Inasmuch as with a constant air quantity the friction loss varies as the square of the velocities of the air through the heater or ducts, it is seen that the resistance due to velocity is the factor to be considered.

In general, the law seems to hold that the rate of heat transmission varies with the frictional resistance of the heater. The relative efficiency of two heaters should be based on the rate of heat transmission under identical temperature conditions and with equal pressure losses in forcing the air through the heater, and not upon the so called velocity through the clear area, which is more or less a hypothetical quantity.

Any decrease in the velocity of the air through the heater means an increase in clear area with a decreased rate of transmission and a consequent increase in total surface required. It also reduces the friction and, therefore, the horsepower required at the fan, with an increase in the size of the fan and a decrease in the size of the motor. To get the same heating effect, the depth of the heater must be inversely proportioned to the square root of the total surface, or directly, as the square root of the rate of transmission is determined by the velocity. The horsepower and the pressure loss vary directly as the seven-thirds power of the velocity when the heater is proportioned to give the same temperature rise to the same quantity of air. The formulas, expressing these relationships, together with their derivation, are all included in an appendix.

It might be well to suggest in this connection that increasing the surface of the heater by the use of the additional sections will not answer the purpose intended, as this would increase the pressure and power required. The increase in surface must be obtained by using larger sections with the greater clear area, so as to handle the same amount of air at the reduced velocity, using the same temperature rise.

The method of assuming a total pressure against which the fan is to operate and then so proportion the various pressure losses as to keep within this limit fails to take into consideration the power cost of the fan. That this is an item of more than secondary importance will be shown, together with the relation of the cost of installation to the subsequent cost of power.

Velocity of Maximum Economy

Assuming a static efficiency of 40 per cent. for the fan —that is, 40 per cent. of the brake horsepower consumed by the fan is usually employed in moving the air against static resistance—the horsepower required due to any resistance or pressure drop through the heater will be the product of the air handled times the pressure drop expressed in inches of water times a constant 0.000405. Expressed as a formula this becomes

$$H = 0.000405\ p\ Q \qquad (1)$$

The yearly cost for the power consumed in overcoming the resistance will be the product of this horsepower times the yearly cost per horsepower. The yearly allowance on the cost of the installation for the interest and depreciation may be varied, according to circumstances, the probable limits being 15 to 25 per cent. yearly for any ordinary installation.

*Abstract of paper read before the American Society of Heating and Ventilating Engineers.

Letting C_p represent the total yearly cost of power at the fan and m the cost per horsepower-year, then

$$C_p = 0.000405\ m\ p\ Q = m\ H \qquad (2)$$

Also letting C_s represent the yearly charge for interest and depreciation, based on the cost of the heater, and S the total square feet of surface in the heater, C_s would equal S times the allowance per square foot for interest and depreciation.

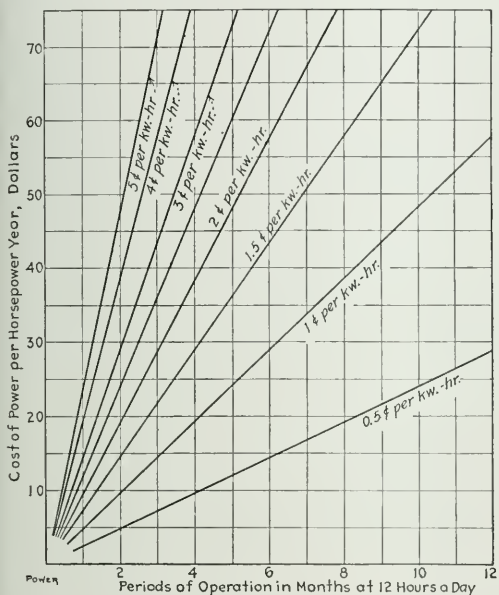


FIG. 1. COST OF POWER PER HORSEPOWER-YEAR

Letting C_{po} and C_{so} be the respective costs at any assumed velocity, V_o, through the clear area, and C_p and C_s be the corresponding costs at any other velocity V, then

$$C_s = C_{so}\left(\frac{V}{V_o}\right)^3 \qquad (3)$$

$$C_p = C_{po}\left(\frac{V}{V_o}\right)^3 \qquad (4)$$

$$\frac{V_m}{V_o} = 0.286\left(\frac{C_{so}}{C_{po}}\right) \qquad (5)$$

$$V_m = 0.66\ V_o\left(\frac{C_{so}}{C_{po}}\right)^{\frac{1}{3}} \qquad (6)$$

If the assumed velocity V is also the most economical velocity, then $V_o = V_m$ and

$$\left(\frac{V_m}{V_o}\right)^3 = 1$$

Assuming then, that the chosen velocity is that which gives maximum economy, equation (5) becomes

$$0.286\ \frac{C_s}{C_p} = 1$$

$$C_p = 0.286\ C_s \qquad (7)$$

This means that for the most economical installation the yearly cost of the power consumed in overcoming the friction of the heater should be 28.6 per cent. of the annual cost of the heater; that is, annual interest and depreciation allowance based on initial costs.

PRACTICAL APPLICATION

As frequent reference will be made to the cost of power per horsepower at the fan, due to forcing the air through the heater against the frictional resistance, Fig. 1 is given to show the relation between this unit and the common one of cost per kilowatt-hour.

Referring to the chart, a plant operating four months a year and twelve hours a day, with power costing 2.5c. per kw.-hr., will be paying $47.50 a year per horsepower. If power costs 1c. per kw.-hr., the horsepower will cost $20 per year. The cost per year, due to the frictional resistance of the heater, may be found by formula (2).

Take, for example, a case where 30,000 cu.ft. of air per min. is to be warmed from zero to 103 deg., by means of a Buffalo pipe-coil heater. Assuming, for convenience, a velocity of 1000 ft. per min., through the clear area, a heater of five sections of 20 rows of pipe deep, with 184.3 sq.ft. of surface per section, will be required. The loss of pressure, due to the frictional resistance, will be 0.48 in. Then

$$Q_o = 30{,}000,\ V_o = 1000,\ S_o = 184.3 \times 5 = 921.5\ sq.ft$$

Operating four months a year at twelve hours a day, the power costing 2c. per kw.-hr., the yearly cost of power will be $40 per horsepower. Then the horsepower required will be

$$H = 30{,}000 \times 0.000405 \times 0.48 = 5.83$$

$$C_{po} = 5.83 \times \$40 = \$233\ a\ year$$

Allowing 15 per cent. on the cost of the installed heater for interest and depreciation on a cost of 35c. per sq.ft.

$$C_{so} = 921.5 \times \$0.0525 = \$48.40\ a\ year$$

Then the maximum economical velocity from equation (6) will be 391 ft. per min.

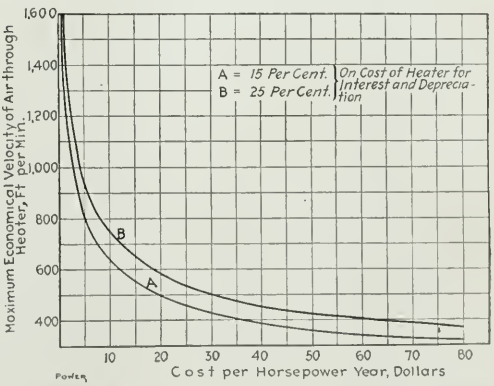

Maximum Economical Velocity of Air through Heater, Ft. per Min.
Cost per Horsepower Year, Dollars
Power
A = 15 Per Cent. On Cost of Heater for
B = 25 Per Cent. Interest and Depreciation
A
B

FIG. 2. MAXIMUM ECONOMICAL VELOCITY FOR DIFFERENT COSTS OF POWER

Substituting the various costs per horsepower-year in this formula, the corresponding maximum economical velocity for each case may be determined and the values plotted, as in curve A, Fig. 2.

From curve A, Fig. 2, it may be seen that if a return of 15 per cent. is desired on the investment, in order to use a velocity of 1000 ft. per min., the power should not cost more than $2.50 per horsepower. This would

only be the case where the fan was driven by a steam engine, and the exhaust steam used in the heating coils, practically using the engine for a reducing valve.

Curve *B* shows the same relation of power cost to velocity when 25 per cent. is allowed for interest and depreciation. The curve is similar to *A*, but shows the greater velocity allowable under this condition.

The curves in Figs. 3 and 4 show the general relation between the cost of the power, due to the frictional resistance, through the heater at the two rates of $10 and

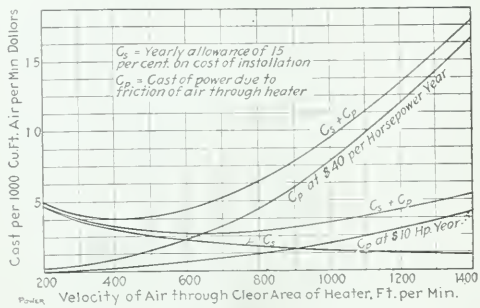


FIG. 3. RELATIVE YEARLY INTEREST AND DEPRECIATION COST ON SURFACE AND POWER COST DUE TO FRICTION OF AIR THROUGH HEATER; ALLOWANCE 15 PER CENT.

$40 per hp.-yr., the interest and depreciation allowance on the cost of the heater and the sum of these two or the total yearly charge. For Fig. 3, an allowance of 15 per cent. is made for interest and depreciation, while for Fig. 4 this allowance is 25 per cent.

The curve $C_s + C_p$ represents the combined cost per 1000 cu.ft. of air per min., due to the interest and power costs for the different velocities. From Fig. 3, it may be

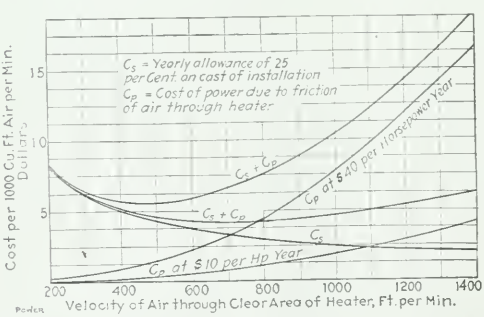


FIG. 4. CHART SIMILAR TO FIG. 3, WITH INTEREST AND DEPRECIATION ALLOWANCE OF 25 PER CENT.

seen that, if power costs $40 per hp.-yr., the lowest total cost of operation will be $3.75 per 1000 cu.ft. per min., at a velocity of 400 ft. per min. through the heater. The velocities at the low points on these total cost curves should correspond to the velocity from the curves in Fig. 2 for the same cost per horsepower-year. The two values of $10 and $40 are taken merely as two representative costs and the curves may be plotted for any other horsepower cost or interest allowance by means of equations (3) and (4).

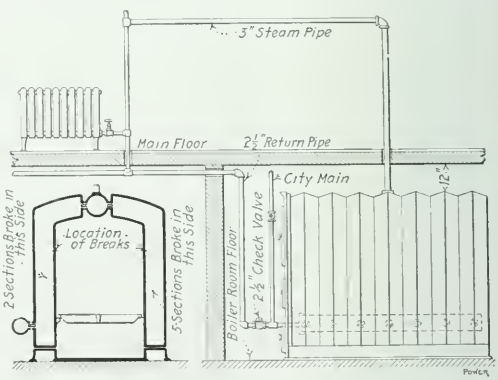
The assumed values used in making the calculations for Figs. 2 to 4, are not intended to apply in all cases, although they do probably represent average conditions. The price per square foot for the heater installed complete, with casing and steam and drip headers will vary more or less with every case, but 35c. was taken as a fair value and is near enough to most installations to form the basis for a comparative study.

[In the second issue following, the balance of the paper, dealing with pressure losses in the piping system, will be published.—EDITOR.]

Water Hammer and a Cracked Boiler

A few days before Christmas I went into a new building which was no warmer than outdoors, due to the fact that several sections of a cast-iron boiler had been cracked. The boiler consisted of 14 sections set vertically, seven sections on each side of the fire and coming together at the top, as shown in the accompanying sketch.

Trouble had been experienced in keeping the water in the boiler ever since it was installed. There would be three-quarters of a glass of water in the boiler every morning, but on raising steam it would go up in the radiators and stay there. Water would not show in the glass again



SECTION OF BOILER AND LAYOUT OF PLANT

that day. When pressure began to raise in the boilers the water-hammer in the radiators was so bad that it was necessary to check the fire.

On Dec. 19 it was cold in the building. There was a good fire, but the steam gage stood at zero. One of the men opened the valve on the city water line. There was a hissing in the boiler, so he shut the valve. The hand on the steam gage jumped up to 3 lb., but soon dropped again. He repeated the same operation with the same result. Then he opened the water valve just so that he could hear a little water going through and went to his work. He had just got to work nicely when a peculiar noise was heard in the boiler. Upon investigation it was found that five sections on one side, and two sections on the other side had cracked and were squirting water into the fire. The fire was pulled and the contractor that put in the heating plant was asked for an explanation. It was his opinion that the pipes were too small and it would be necessary to repipe the building.

Duluth, Minn. O. L. SHERMAN.

EDITORIALS

Receiver and Condenser Explosions

The occasional failure, under pressures which they were never intended to carry, of intermediate receivers of steam engines, condensers, etc., suggests a more careful provision against the accumulation in these vessels of the pressure which exists in the boilers to which they are indirectly connected. Some time ago, a receiver exploded because the engineer admitted steam to the high-pressure cylinder with the relief valve open, blowing directly into the exhaust, and, hence, into the receiver. There was, therefore, nearly as much pressure in front as behind the high-pressure piston. The engine would not start, so that there was no relief for the receiver through the low-pressure cylinder and the pressure built up in it until it exploded.

Last month a condenser exploded, with disastrous results, on the French battleship "Messena." The shell of a surface condenser would sustain very little internal pressure. It is ribbed and stayed to withstand external stresses, for the pressure outside is supposed to be greater than that in the interior. Yet, a surface condenser is a closed vessel in more or less direct connection with a steam boiler under pressure. Suppose this connection to be through a steam turbine. It is not inconceivable that, with the unit shut down, sufficient steam might pass through the turbine to create a dangerous pressure in the condenser shell if the discharge through the air pump were obstructed.

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Automatic Appliances for Boilers

That the trend in modern power-plant practice is to eliminate the human element, as far as possible, is clearly indicated by the many devices on the market for the automatic operation and regulation of equipment. As a rule the introduction of any device that will relieve the attendant of some of his many duties, particularly the onerous ones, will make for the better operation of the plant as a whole. This is not necessarily because an automatic device is any better than a man, but because he is able to devote more of his energies to other things, such as planning new methods or economies, etc.

There are two sides, however, to the question of installing automatic devices wherever possible. One of the principle negative contentions is that the adoption of a device, such as a boiler feed-water regulator, for example, will engender carelessness and inattention on the part of the water tender. Those opposing this view argue that any attendant who will become lax and negligent because of some mechanism installed to assist him, is not desirable under any conditions.

However, this is aside from the present intention, which is to call attention to the careful consideration that should be given to the way in which automatic governing and regulating devices and so on are applied and how the connections are made. Sometimes it happens that two or more such devices which control or regulate correlating equipment will so act as to produce opposite rather than similar effects on the apparatus governed. As an illustration, consider first an individual boiler that is self-contained in every respect and that is served by the usual stack, stoker, etc., and operates under forced draft in addition to that produced by the stack. Assume that in the main steam header, or possibly in the goose-neck connecting the boiler and the header, is a nonreturn valve of the type which responds to a drop in steam pressure on either side of it; and that the stack damper, as well as the stoker and fan, are controlled by the usual automatic regulating devices. Suppose these regulators are connected to the steam line between the nonreturn valve and the boiler. If a tube should burst, the drop in pressure would close the valve and open the damper and speed up both fan and stoker. If a break should occur in the steam main beyond the nonreturn valve, the latter would close; consequently the pressure in the boiler would build up, thus closing the damper and slowing down the fan and stoker.

Suppose the regulator connections to the steam line are made on the far side of the nonreturn valve from the boiler. In the event of a tube bursting, the valve closes but the other appliances are not affected, unless it would be after some little time has elapsed in which the pressure in the steam line has fallen off. If a break occurs in the line on the far side of the valve, the latter will close but the damper will open and the air and coal supply will be increased. The only advantage in connecting up this way is that the bursting of a boiler tube is more frequent than the bursting of the steam pipe.

As another illustration, consider a plant containing a number of boilers each equipped with individual nonreturn valves in the goose-necks and only one regulator to control the dampers and one to control the air and coal supply for the entire plant. If these regulators are connected to the main steam header, the bursting of a tube in one of the boilers will simply have the effect of closing the nonreturn valve serving that particular unit; there being no effect whatever on either of the two regulators. If, on the other hand, a break occurs in the steam line, all of the valves will close; the dampers will open; and both the fan and stokers will speed up. To prevent this, the regulator connection should be made to all of the boilers in a small plant or, in a large plant where this is not practicable, to several batteries at points between the boilers and nonreturn valves. This will prevent increasing the air and coal supply when a break occurs in the main steam line and the effect of a tube bursting in one of the boilers will be practically negligible.

From the very nature of these appliances, the functions they are designed to perform and the methods of their operation, it is evident that they work at times to cross purposes. For example, the nonreturn valve is a safety device, designed so that it will close and shut off the steam in case of any unusual happening, whereas the

damper, stoker and fan regulators are intended to control their equipment so as to get uniform operation. The result is that the latter devices will endeavor to maintain a uniform operation under all circumstances and conditions and the more upset these become the harder they will work, even when this is the very thing that is not desired.

Thus it may be seen that the elimination of the so called human element in the boiler house is impossible, no matter how many automatic devices are applied. When everything is running along smoothly there may not be so much required of the attendant in the way of actual and constant attention, nevertheless, when an accident happens or an emergency arises no device so far found is able to take his place.

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The Society for Electrical Development

Since commercial growth is the ultimate aim of all industries this new organization, committeed to the commercial side of electrical engineering, has before it great possibilities. Heretofore, the technical side of electrical engineering has been well taken care of, through a number of representative societies, but the business side has been left largely to individual effort.

The Society for Electrical Development aims to bring together the various interests concerned, such as central stations, electrical manufacturers, architects, contractors, etc., in a sort of mutual aid spirit, and it also proposes through an educational and publicity campaign to greatly extend the use of electricity for industrial and domestic purposes.

In spite of several protestations of public-spirited policies, the program is purely a business proposition and as such is perfectly legitimate. However, it is no secret that the society is to be used incidentally as a weapon by the central-station interests in their war against isolated plants; in fact, several of the speakers at the meeting inferred as much. One of the most effective means of accomplishing this end is the plan for establishing a closer relation between the central station and the architect, builder, and city officials, the central-station engineers to furnish the necessary engineering advice in such problems as may arise. If present practices are to be taken as a criterion, such information will often be strongly biased and we believe the architect and builder should be warned against accepting such information without the most crucial analysis, for in the end the owner is the loser, and the architect and builder are morally responsible to the owner.

Another line of action was suggested in the address of Mr. Doherty who decried the present supervision and regulation of central stations by public-service commissions.

Viewing the question from a strictly independent standpoint, we believe the society has a wide field of usefulness in promoting electrical progress, extending the use of electricity with more efficient application and educating the public as to its possibilities. Insofar as such applications lie within the field of the central station the latter is entitled to all the benefits which it is likely to derive. But where it attempts to further certain mercenary policies under the disguise of more lofty aims and endeavors to use the influence of such a society to hinder or frustrate the efforts of the people to protect themselves through public-service commissions against such extortions and discriminations as have often been witnessed in the past, then the public should become acquainted with the facts and the allied interests, such as manufacturers, architects and builders should be on their guard.

⁂

Efficiency in the Power Plant

The slogan of the day is efficiency. Particularly in engineering lines, there is a marked tendency toward seeking out the sources of waste and as far as possible destroying them. Much has been accomplished, but often too little consideration is given, in the plans of the efficiency expert, to the factor of the operating man. No amount of planning, scientific arranging and organization will bring the desired results unless the man on the job is behind the movement. Tactlessness has often resulted in making an enemy of the operating man where lucid explanation would have made him willing and anxious to coöperate.

In the last analysis the best interests of the owner of a plant and the men who run it for him are identical. An increase in efficiency of one always betters the condition of the other, and the matter of efficiency is really much simpler than might be supposed from reading some of the literature on the subject. Any man is an efficiency expert who keeps his eyes open and first sees where methods are wrong, and then thinks out a way to correct them. The whole secret lies in a habit of mind. Observation and ability to think straight are the necessary qualities.

For example, a man who does a given task daily and grumbles at the excessive labor involved, will probably always be at that job until he is fired. The man who, on the other hand, doing the same work, first wonders *why* it is so hard, then finds out that it might be done an easier way, and finally discovers that easier way, will not be wasted long in that niche—he will be needed higher up.

It is the attitude of mind that counts. Confidence is power, and confidence is bred in accomplishments and knowledge. It is the man who wants to know "why the wheels go round," and perseveres till he finds out, that does things in any line. If the operating man does not get anywhere, the blame never lies in "lack of opportunity," "being tied to a battery of old tea-kettles," or "the boss don't know me." It rests in his own attitude of mind. Get the thinking habit—acquire curiosity—look and ponder—and the rest is just hard work that never killed anyone yet.

⁂

A bill requiring building constructors to be licensed is to be introduced into the New York State Legislature, according to a daily press report. No matter what its merits, we can predict the fate of the bill, for this state hasn't yet got the right perspective on would-be laws that would make for the greater safety of the people. Perhaps, if this bill does pass and the lawmakers can be brought to realize that a collapsing building is not so very much more effective as a life extinguisher than a bursting boiler, there may be some chance of adopting a boiler-inspection law and even an engineers' license law in course of time.

READERS WITH SOMETHING TO SAY

Adjusting Lost Motion in Pump Valves

Setting the valves of a duplex pump is generally considered simple and one of the first things the young engineer is taught, but with pumps in which the valves are set with lost motion it becomes a question to some as to just how much play to allow. A simple rule to follow is to make the combined total lost motion or clearance equal to the width of one steam port. For instance, in Fig. 1, if the width of the port is $\frac{7}{8}$ in., the clearance between the lug and the nuts at *C* and *D* should be $\frac{7}{16}$ in. each.

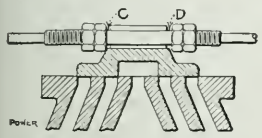

FIG. 1. SHOWING CLEARANCE BETWEEN VALVE STEM NUTS

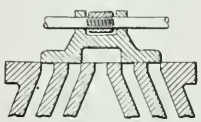

FIG. 2. VALVE STEM WITH ONE NUT

Some types of pumps have a large nut between the jaws of the upper side of the valve, Fig. 2. In this case the clearance is divided and the amount determined by the pump maker. The only advantage in having the clearance adjustable is that sometimes a pump is used with a considerably lower pressure on the water end than that for which it was designed. It is then sometimes necessary to decrease the lost motion which shortens the stroke of the pump, preventing the steam pistons from striking the cylinder heads. This is only the case where the service is very low and the amount of steam used is slight.

JOHN F. HURST.

Louisville, Ky.

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The Deadly Monoxide

Carbon monoxide is a product that has no place in a well regulated furnace. Besides the lack of complete combustion attending its formation, it is highly dangerous, when mixed in proper proportions with air, because of its explosive quality. Although at first glance it might seem impossible that the amount of this gas present in the flue could rise to a point where it would be a menace to safety, this very thing has happened. In one instance the fact that the boiler-room man did not realize what an amount of the gas was being formed at times, nearly resulted in a bad explosion.

This plant consisted of a battery of nine horizontal return-tubular boilers arranged in one long row and all connected to a common flue at the back. Two of the nine were very old and to get more work out of them in their old age, steam jet blowers had been installed. All the boilers were hand-fired and all operated under natural draft except the two in question. To prevent leakage around the ashpit doors the latter were sealed tight and the firedoors were a good snug fit. The grates were of the sawdust type with holes not over $\frac{3}{8}$-in. in diameter.

The management was considering the purchase of a different brand of coal from that previously used, and before deciding the matter, engaged a testing engineer to run comparative tests on the old and new coal. The engineer ran foul of the boiler-room man at once, as the latter was one of those that believes no outsider can tell him anything about *his* boiler room, but no open rupture occurred.

Along in the second day of the run, the testing man made his hourly Orsat reading and found the percentage of CO had jumped in an hour from one-half of 1 per cent. to *over 14 per cent.* Unable to believe his own figures, he took another sample, renewed his reagents and tested again. This time the result was nearly 15 parts of the deadly monoxide gas.

There being no longer any doubt, the engineer called the head fireman and told him what he had found, explaining the danger. The boss of the boiler room was puzzled and incredulous. He had no explanation to offer because he did not *know* his own boilers and what really happened inside them. Then the testing man thought of the steam-blast boilers and their sealed ashpits. In two jumps he reached the steam valve. Sure enough, it was closed tight and those two boilers were simply generating carbon monoxide, because sufficient air could not reach the fires. It developed then that it was the custom to shut the steam off tight when necessary to clean fires or lay off those two units, and for more than a year this had been going on with an excellent chance each time for an explosion that might have wrecked the plant. That the correct mixture of CO and oxygen had never been attained was pure luck.

When the testing engineer made his discovery it was within 2 per cent. of the danger point. Therefore, the latter laid down a rule that the steam at the blower was always to be turned on, at least the valve cracked, while he was on the job—and reported the matter to the management, and recommended for the safety of the plant that the steam valves in question be arranged so that it would be impossible to quite close them. The general manager of the works, who knew little or nothing of boilers or their operation, was greatly excited and immediately wanted to discharge the whole boiler-room force, but the testing engineer dissuaded him from doing so.

This incident is related to bring out the value of an inquiring habit of mind. If the head fireman had been of the type that thinks for himself, would he have sat complacently over a potential blowup and not found it out? Of course, if the plant had been one where Orsat tests are the usual routine the trouble would have been found at once, but without any testing apparatus an efficient boiler-room man would have made all the more sure that the battery was in proper shape. Such a man

would have stopped to reason, just as soon as the steam jets went in—"How is this going to effect combustion?" He would have considered the sealed ashpits, the lack of air without the blower and concluded that shutting off the latter simply turned his boilers into gas producers. This man did not think and nearly lost his job, if not his life, in consequence. There is no doubt that many disastrous steam explosions of boilers have been caused primarily by a CO explosion which throws the boiler off its setting and breaks the steam connections, and the percentage of CO would never have reached the danger point if the man in charge understood the character of this gas and the conditions under which it is formed. Give a fire air enough and there is no chance of trouble.

H. R. Callaway.

New York City.

Power Pump Troubles

Many times troubles develop in power pumps which are difficult to locate. Probably the greatest source of trouble is in the valves, which become worn and uneven, and if they turn slightly on the stem the port opening is not properly closed and excessive slip results. Other causes of valve trouble are sticks, leaves and rubbish clogging the seats or blocking up the valves. Valve stems sometimes work loose and drop out and the valves that do not fit properly become wedged or stuck.

Sometimes difficulty is experienced in lifting water by suction, which may be due to various causes. The pump and the suction line should be well primed before starting and for long or high suction lifts a foot valve of a large valve area should be provided.

All air pockets should be carefully avoided in the suction line, and pumps which are so designed as to form air pockets in the suction-valve chamber should be avoided. Plunger or piston and piston-rod packing should be of good quality and properly installed. In installing a pump it should not be forgotten that pipe friction is to be overcome in the suction as well as in the discharge line; therefore the pipe lines should be kept free from sharp bends.

Air in the suction line will cause pounding. Hence all leaks should be repaired and it should be seen that the suction pipe is properly submerged at the intake.

Long suction lines will sometimes knock from the momentum of the column of water which must be started and stopped. A suction or vacuum chamber to cushion the shock will remedy the trouble. Hot water will evaporate in a vacuum and cause a severe knock if lifted by suction. Therefore, the water should be brought to the pump under a slight head if possible.

As worn crank- or pinion-shaft bearings will vary the shaft centers and cause noisy gears, the gearing should be properly lined up and the centers properly adjusted and the bearings rebabbitted. Cast gears may have one or two large teeth in the gear or pinion which will cause a noise at each revolution. Filing down to a proper size will remove the noise.

Single pumps, and even duplex and triplex pumps, will occasionally develop pounding in the discharge line. The cause may be a fluctuating discharge, which may be remedied by a discharge air chamber, proper care being taken that it is supplied with air. Faulty check valves in the discharge line, improper arrangement of piping or frequent opening and closing of the discharge valves may cause knocks.

Every power pump should be fitted with one or more relief valves placed close to the pump to prevent breakage. A check valve in the discharge line will take the load from the pump-discharge valves during a shutdown.

G. H. Bridges.

Holyoke, Mass.

Experience with Water Softening Plants

In the hope of getting engineers to tell of their experience with water-softening plants, I submit the following:

My first experience was with feed water, taken from a well, the hardness of which, by Dr. Clark's soap test, was 34 deg. About 20 deg. of this hardness was temporary, the remaining 14 deg. being permanent. The hardness was due to carbonate and sulphate of lime with a little magnesia, and varied with the season, rainfall and melting snow in the hills, causing a variation of 4 or 5 deg. We made a rough test of the water daily as follows:

Seventy c.c. of the well water was tested with the soap solution and the total hardness noted. At the same time a quantity of the well water was subjected to prolonged boiling. Carbonate of lime is insoluble in water and can only be held in solution in the form of bi-carbonate. Boiling liberates the carbonic acid and the bi-carbonate then becomes carbonate and is precipitated. After cooling, 70 c.c. of the boiled water was tested with the soap solution and the hardness noted as permanent hardness, the difference between this and the total hardness previously noted being the temporary hardness.

To estimate the magnesia, about a liter of well water was treated with a gram of ammonium oxalate. This precipitated all the lime and after filtration 70 c.c. of this water was subjected to the soap test and any hardness above 1 deg. was multiplied by the fraction $^{42}/_{75}$, the result giving, approximately, the hardness due to the magnesia. These tests are rough and such as any engineer can make. They enable him to discover if there is any radical change in the water.

The plant we had for treating this water was designed to remove the temporary hardness only, and was worked on the Clark system. By this method, caustic lime is added to the water. This neutralizes the excess CO_2, and by so doing the lime originally in solution and the caustic lime are precipitated as carbonates. The capacity of the plant was 12,000 gal. per hour and the arrangement was as follows:

The water from the well was pumped to a mixer where it received the requisite amount of caustic lime. From the mixer it passed to a settling tank where precipitation took place; the water, turbid with lime, entering at one end and flowing over a weir at the other end, comparatively clear, to the filters. After passing through the filtering medium, which in this case was sail cloth, the water passed to the storage tank.

This plant worked fairly well, the temporary hardness being reduced 17 deg. If, however, the plant was worked to its full capacity there was likelihood of trouble through the softening process being continued in the pipes, tanks, etc., beyond the filters, carbonate of lime

being deposited in places where it should not be. The filters were also likely to give trouble. As the filtration was through one ply of sail cloth only, if a hole developed, free lime entered the piping, etc., and was precipitated therein. Had there been double filtration there would have been less chance for unfiltered water to enter the piping.

Although these defects were against the plant, there was a great reduction in the hardness of the water, practically the whole of the carbonates, together with a part of the magnesia, being removed. The softened water was also free from organic contamination.

The next plant I had charge of was designed to remove both the temporary and permanent hardness from a similar water to that treated in the first plant. The makers of the apparatus promised a reduction of 29 deg. in the hardness by means of the lime-soda process. In this plant, which had a capacity of 20,000 gal. per hr., the water was pumped to a mixer, where it was automatically mixed with the right amount of soda and caustic lime. The water and chemicals then passed to a settling chamber where most of the precipitation took place, and from thence through three wood wool filters in series, to the storage tanks.

This system had triple filtration as against the single filters of the first plant, and, although the water remained for several days in the storage tanks, there was no precipitation therein. This showed that there was no subsequent softening action going on after the water had passed through the plant, and that no sediment was passing the filters.

We could reduce to 4 deg. hardness quite easily, but our experience showed us that for boiler feeding, pitting of the plates was likely to happen by getting the water down to a minimum hardness. We found that it was better to work at 7 deg., as a slight excess of soda in the water caused foaming with all the bother at the engine that foaming causes. This plant gave excellent results and our boilers greatly benefited thereby.

We had water-tube boilers and it was quite a common thing to shut down for bagged and leaky tubes. As many as ten tubes have had to be removed in a day prior to installing the softening plant, and now this trouble has practically ceased.

My next experience was with with a plant for dealing with quite a different water, the hardness of which was 14 deg., 9 deg. being permanent and 5 deg. temporary. This water was obtained from a source little better than a sewer and there was much solid matter in suspension apart from the hardness. It was originally intended that this water should be simply filtered and freed from organic impurities and no provision was made for reducing the hardness appreciably. The process was as follows:

Pumps drew from the water supply and chemical tanks, and delivered from a closed, vertical cylindrical tank, the outlet of which was connected to pressure sand filters. In the chemical tanks was a solution of aluminum sulphate and a valve in this tank was so regulated that a sufficient quantity of the reagent was drawn into the pump along with the untreated water.

This reagent assisted the purification in two ways. It caused the suspended matter to coagulate and be precipitated in the settling tank, and, secondly, an insoluble gelatinous substance was formed in the filters, which materially assisted filtration and was capable of destroying micro-organisms and extracting coloring matter. The water left the filters remarkably clear and free from impurities other than the lime and magnesia salts in solution.

To eliminate these salts and thereby soften the water, a chemical pump was installed, which was actuated by the main pump, and which drew liquid from another tank containing a lime-soda mixture. The capacity of this pump was such that a close approximation to the correct amount of reagent was mixed with the water on the delivery side of the main pump, finer adjustments being made by varying the strength of the solution. From this point the process was the same as it was prior to the adoption of the softening apparatus. With the addition of the lime-soda, a reduced amount of aluminum sulphate is required. The main pumps are of the duplex type, and the advantage of having the chemical pump driven by the duplex pump is that any variation in the length or number of strokes causes a like variation in the speed of the chemical pump, thereby maintaining the correct ratio between the amount of water and reagent.

The plant is capable of handling about 50,000 gal. per hr.

Any person who has seen the sludge taken from a softening plant, treating only moderately hard water, will be convinced that the heater and boiler are not the best places to soften feed water.

For boiler feeding, it is not advisable to soften the water to the lowest possible limit when working with the lime-soda process, or there may be trouble from foaming. It is better to have a margin of 2 deg. or thereabouts.

Mac Dickman.

Paisley, Scotland.

Putting in a New Piston

A quick way of putting in a new piston and rod is as follows:

Get a straight stick 1½ in. wide and 8 in. longer than the cylinder. Then measure the inside length of the cylinder, from the crank-end head to the outside edge of the head end, graduating the stick in inches with a thin knife blade and square. If the length of the stroke is 48 in., measure off 48 in. on the stick from the end.

Then measure the thickness of the piston and mark off this measurement on the stick from the stroke measurement, which would be the length of stroke plus the thickness of piston. Next measure the thickness of the cylinder head from the flange with the gasket in place. This will leave but very little space on the stick measurement of the length of cylinder, say $\frac{5}{16}$ in., which is the total clearance for both ends of the cylinder, or $\frac{5}{32}$-in. clearance for each end between the piston and each head.

Then place the engine on the head-end dead center, and screw the piston rod into the crosshead until the piston is in the cylinder from the outside edge a distance equal to the thickness of the cylinder head, plus the clearance, $\frac{5}{32}$ in. Then tighten up the crosshead nut on the piston rod, secure the cylinder head and if the measurements have been correctly made the piston has equal clearance at each end of the cylinder.

A. I. Haight.

Kalamazoo, Mich.

QUESTIONS BEFORE THE HOUSE

Logical Unit of Power

Replying to Mr. Liddell's letter in the Feb. 4 issue, on the "Logical Unit of Power," I would say that, in the ultimate analysis, the ampere is determined electrolytically—not by an ampere balance. However, both the ampere and the ohm, as determined fundamentally in a standard laboratory, are based on gravity, as are all other units representing or contributing to work, excepting those of space. But the instruments used universally for indicating amperes and ohms and watts, give the same indications everywhere, whereas the common pound and ounce weights have not the same absolute values at all latitudes.

If ammeters and wattmeters were all made with retractile weights instead of springs, the relation between electrical and mechanical measurements would be the same at all points. When I said that the kilowatt is the same everywhere within man's reach, I meant the kilowatt as universally measured, not as derived from original determinations made at Washington or Paris.

The question whether the kilowatt can be measured more closely than the mechanical equivalent is irrelevant; also whether the operating engineer uses 746 or 745.6 watts as the electrical equivalent. Undoubtedly, both 746 watts and 550 ft.-lb. per sec. will always be used as horsepower equivalents in ordinary everyday work, but that has nothing whatever to do with the question of whether it is more expedient in scientific work to take 746 as the exact equivalent and let the foot-pound values wabble, or *vice versa*.

C. P. Poole.

Atlanta, Ga.

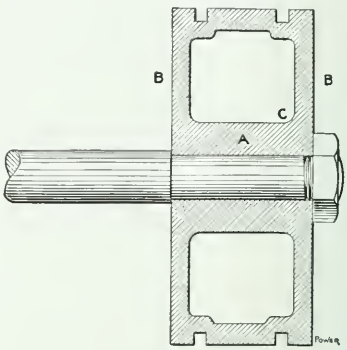
Cause of Piston Fracture

In the Nov. 5 issue, H. R. Rockwell relates his experience with fractured pistons on a 12x12-in. duplex single-stage air compressor, working against 100 lb. receiver pressure. Three of these pistons fractured one after another, and Mr. Rockwell asked what was the cause of the trouble.

I believe the initial cause of the failure of the pistons was their weak design. By referring to Mr. Rockwell's illustration of one of the fractured pistons, it may be seen that all the corners on the inside of the piston are square and sharp. This is a feature that should be avoided when possible in machine design.

The action of the iron in such shapes when poured and cooled at the foundry would be to pull the hub from the piston because the sand of the core which forms the shape of the inside of the piston, will keep the hub *A* hot after the faces *B* have cooled off and later when the hub *A* cools, there will be a severe shrinkage strain at the point *C*, where the hub joins the inner side of the piston. If the interior of the piston had been shaped like that shown herewith, having fillets instead of sharp corners, the castings would have had sufficient strength to resist the shrinkage strain because with rounded corners there would be no points from which a fracture could start. This is on the same principle as drilling a hole in a boiler plate at the end of a crack or fracture to prevent an increase of the length of the crack.

The force that actuates the compressor piston is transmitted to it by the piston rod. The resistance to be overcome in this instance is about 11,300 lb., which tends to push and pull the middle out of the piston which intermittent action will soon cause a piston to fail, as described by Mr. Rockwell.



Piston with Rounded Inner Corners

J. W. Parker.

Clinton, Mass.

In reply to H. R. Rockwell's request, regarding the piston troubles he has had with his air compressor, I think his trouble was due to presence of oil in the piston. The heat of compression caused the oil to vaporize or gasify, and later on, during the ordinary operation of the compressor, the heat of compression became great enough to ignite this gas or vapor, and caused an explosion of the piston. As he has adopted the use of a solid piston he will not have this trouble again, but if he continues to use the same oil, and if not very cautious, it may result in the explosion of a cylinder or pipeline.

E. H. Hart.

Baskett, Ky.

Although I cannot offer any solution as to the cause of the piston fracture, described by Mr. Rockwell, it recalls an experience of mine with a similar trouble. I was employed as foreman in a shop which made a specialty of making horizontal cross-compound engines. We also did much work in millwrighting and general repairs. One morning we received an urgent call from a mill in a neighboring town, requesting us to send a man over immediately, as the engine was completely wrecked.

On arriving at the plant I found the high-pressure cylinder had been badly damaged. The back cover of the

cylinder lay against the wall. The words of Mr. Rockwell accurately described the condition of the piston, "nothing was left on the rod except the hub or eye through which the rod passed," and the piston rod and connecting-rod were both badly buckled. Finding that the low-pressure side was intact and in good condition, I first set about getting this engine running, which carried the greatest part of the load.

On going back to the wrecked or high-pressure side, it was soon apparent to me that the trouble was brought about by the connecting-rod cotter (key) working out and I explained to the mill manager that my experience was that sufficient warning by knocking or bumping was usually given in circumstances of this kind, to allow of shutting down the engine before any serious damage could be done. In reply to my inquiry as to where the engineer was when the accident happened, the manager replied, "At the other side of that field," pointing to a field about 600 yards away. Evidently the engineer made a hurried exit from the plant as soon as he heard a slight knocking in the cylinder.

F. P. Strachan.

Belfast, Ireland.

Dalton's Law in the Steam Plant

The letter by Louis Grossbaum, published in the Feb. 4 issue of Power, commenting upon my previous article on "Dalton's Law in the Steam Plant," is of interest, because his statements are correct, but at the same time they do not contradict any of the statements in my previous article. His letter does serve to show how loosely many engineering terms are used.

Mr. Grossbaum discusses the flash point of oil purely from an academic standpoint and assumes it is used for determining *the temperature at which explosive mixtures of oil vapor with air are formed.* While this is a physical fact, engineers use "flash point" for determining the volatility of cylinder oil, and this is what I had in mind. That is, the flash point was considered merely as a measure of the temperature at which a certain rate of evaporation would occur from the surface of oil. With this qualification in mind it is evident that none of the remarks are misleading. The statement that the same flash point would exist under 150 lb. air pressure was perhaps unfortunate, but I was merely using air as an example of another gas in contradistinction to 150 lb. steam pressure. I might have said 150 lb. pressure of carbon-dioxide gas (a nonsupporter of combustion) and from an engineering standpoint the oil would still have a flash point the same as it does with steam, although as Mr. Grossbaum points out, in the latter case it would be impossible to obtain a physical flash.

Engineers in this country use flash point to tell them whether or not, when they inject a drop of oil into a cylinderful of steam at a given temperature, it will immediately flash into a vapor or will maintain its liquid state and have some value as a lubricant.

It might also be well to point out here that with a large body of oil in a cylinderful of steam it would be possible for enough of this oil to evaporate to build up a pressure of its own vapor so that the flash point might be raised, but when it is considered that under ordinary circumstances only a minute drop of oil mixes with a cylinderful of steam, it is seen to be practically impossible for so small an amount of oil to build up an appreciable pressure of its own vapor.

I am still sure that the author of the book referred to in the original article was laboring under a delusion and was not familiar with the practical application of Dalton's Law. For in speaking of the fact that 150 lb. steam pressure raises the flash point he says: "This will explain why it might be possible to use a cylinder oil successfully for lubrication under superheated-steam conditions where the temperature of the steam might even be a good deal higher than the flash point of the oil measured under atmospheric conditions."

In other words, he would have us believe that the steam pressure would tend to raise the flash point and thus hold the oil in its liquid state in spite of the high superheat. It is this fallacy that I wished to combat, for, as I pointed out in the article, the steam (another gas) pressure is not going to raise the flash point. So let no engineer delude himself into believing he can use a cylinder oil of low flash point and expect the steam pressure to hold the oil in its liquid state.

It might not be amiss to mention at this point that if engineers are going to use the term flash point, they should, in order that they have an absolute basis of comparison, state under what atmospheric conditions the test was made, that is, barometric pressure, humidity, velocity and temperature of the air in the rooms, etc., for, of course, if there were a strong current of air passing over the oil under test, a large proportion of the vapor would be carried away and it would be impossible to get a mixture rich enough in ignitable vapors to give a flash.

The importance of these variables is now appreciated by chemists and engineers who make a specialty of oil testing, for whereas the "open flash test" was formerly accepted, the "closed flash test" is now considered more reliable and apparatus has now been perfected for controlling and measuring the extraneous variables that affect the flash point.

It is interesting to note that the use of "flash point" as a measure of volatility is only roughly correct as has been proved by recent experiments. Archbutt has perfected an instrument known as a vaporimeter for determining the loss in weight of oil at any given temperature. The principle consists in passing a known quantity of air or steam at a known temperature over a given weight of oil and determining the rate of evaporation by noting the loss in weight of oil. He determined the following relations between volatility and flash point.

	Sp. Gr. at 60 deg. F.	Flash Point,* deg. F.	Loss Wt. in 1 hr. at 370 deg. F. in 2 liters per min. Per cent.
American cylinder oil	0.902	585	0.12
American cylinder oil	0.898	512	0.55
American cylinder oil	0.893	424	4.18

*Tests made on a Pensky-Martens instrument, closed "flash test" apparatus.

This shows that the use of "flash point" for measuring the volatility is probably close enough for practical purposes, but that no known simple relation exists between the two. Might it not be well for engineers to cease using the term "flash point" as a measure of the suitability of any given oil for use in steam-engine cylinders under various degrees of pressure and superheat, and to adopt some more rational standard based upon the rate of evaporation under standard conditions?

New York City. George F. Fenno.

Feed Water Heating and Pumping

The discussion of the pumping problems in the article, under the above title, appearing Feb. 4, is not in accordance with present and coming American practice. We differ at present in that the single pump is not the accepted standard and in that the turbo- and electric-driven centrifugal pumps are replacing reciprocating units in a large number of the modern installations.

The preference for single or duplex pumps is largely a matter of individual taste. The single pump offers as advantages: fewer boxes and glands, full stroke and lower steam consumption, outside adjustment of valves.

For its advantages, the duplex pump offers: positive action, less operating trouble as practically two pumps are provided, steadier flow to boilers, thus permitting higher speeds without jar to the boilers, and less space occupied.

For the centrifugal pump used aboard ship, the regulation is the main problem. If electric power is obtainable, it may be used. However, it is preferable to drive boiler feeders here by the same source of power that actuates the main machinery. Steam turbines have been perfected that will regulate within boiler pressures from 25 per cent. below to 15 per cent. or more above standard conditions. Further, the steam turbines are used largely on land and could be used to advantage for marine work.

In present plants, where boiler feed is being satisfactorily handled by single or duplex pumps, it may be all right to accept the old situation. However, every new plant should seriously consider both types of machinery. The low first cost will protect the reciprocating pump on plants below 1000 boiler horsepower, as the steam saving effected would hardly offset the first cost. As an example, take a plant of 750 boiler horsepower operating under 100 lb. steam pressure.

A duplex pump would have 8-in. steam cylinders, 5-in. water cylinders, 10-in. stroke, and would deliver some 55,000 lb. of water per hr. at a piston speed of some 30 ft. per min. This pump would cost around $200 and, operating at this slow speed, should last indefinitely with replacements of valves and gaskets. The steam consumption would be at least 150 lb. per hp.-hr., or 639 lb. per hr.

This same boiler could be fed by a 2-in. two-stage centrifugal pump direct connected to a steam turbine operating at 2600 r.p.m. The pump and turbine would cost about $600 and would require not over 450 lb. of steam per hour, or a saving of 169 lb. per hr. over the reciprocating unit.

An electric-driven centrifugal pump would cost about $500 and would require but 300 lb. of steam per hour under the worst conditions. Both of the centrifugal installations would be good for boilers with double the capacity. Here, it will be seen that the first costs approach, while the saving effected in steam consumption increases directly as the horsepower of the boilers.

Large users of power all over this country are meeting the new conditions and accepting the improved machinery. Steam reciprocating units are being replaced by centrifugal units. First cost once out of the way, as is the case where the capacity of the plant is above 1000 boiler horsepower, the new pumps speak for themselves.

The saving in steam consumption amounts to about 50 per cent. and the complete unit requires much less room. it further means that the flow to the boilers is smoother and without the shock to the piping and boiler tubes obtained when reciprocating pumps are used. A final saving seldom considered, is the fact that the exhaust from the steam turbines is free from lubricating oil, which means purer water to the boilers.

The reciprocating pump will continue to be used where the capacity desired is small or where the head for discharge is excessive. The centrifugal pump costs more, but the saving effected by its use will more than counterbalance this disadvantage.

F. C. Wight.

Dayton, Ohio.

World Beating Discoveries

In the Feb. 11 issue, under the title "World Beating Discoveries," I fear that Mr. Booth has given a grain of comfort to the promoters of the scheme for the centrifugal separation of carbon dioxide from its associate gases. That the scheme is not impossible but only impracticable may be the stand taken by these gentlemen.

The inference from Mr. Booth's article is that a well insulated vessel containing a mixture of gases should show a greater percentage of the heavier gases at the bottom. This I do not believe, because if the kinetic theory of gases is correct, the only restraints on the movements of the molecules of the gases would be a reduction of temperature and the sides of the vessel. This in the case of a mixture would affect all of the gases composing the mixture and we would still have the intimate mingling caused by diffusion.

Does not the phenomenon known as diffusion (the power of which is illustrated by an example in Mr. Booth's article) preclude the possibility of a separation by the action of gravity?

It seems to me that as long as there is heat enough to maintain the gases in a gaseous state, there will be more or less perfect diffusion and that separation must be effected by means other than gravity.

Kansas City, Mo. C. O. Sandstrom.

Evaporative Test of Cylinder Oil

C. E. Fairbanks, in the Jan. 7 issue, describes a method of testing cylinder oil by evaporating it from an ordinary blotter, which gave just the reverse results from our experiments with cylinder lubricants.

Some months ago, we were sent a 5-gal. can of a new cylinder oil to try. It was also guaranteed that only one-half as much of the new oil would have to be used as of the old. In the afternoon of the first day we began using the new oil we experienced trouble, for we could not get enough of the new oil through the lubricator to lubricate the cylinder walls, valve seats and piston rod.

The test we made of the oil, both the new and the old, was practically the same as that made by Mr. Fairbanks and, as related in his letter, the new oil showing the same as that of No. 2, and the old oil showing up just a little better than No. 6 of the photographs submitted by Mr. Fairbanks in the Jan. 7 issue. Our boiler pressure is 140 lb. gage; the engine is a 20x48-in. Corliss.

Fort Madison, Iowa. Thomas C. Robinson.

INQUIRIES OF GENERAL INTEREST

Solid vs. Built-Up Piston—Why is a solid piston preferred to a built-up piston in a high-speed engine?

C. E. A.

At a high speed of rotation and frequent reversing, there is more danger with a built-up piston that parts may become separated and do damage.

Feed Water Temperature—How hot is it possible to get feed water in an open heater?

G. W. D.

Water in an open heater, i.e., one in which the water is under only atmospheric pressure, cannot be heated to above 212 deg. F., as further heat passes off in evaporation as fast as it is added.

Bleeder—What is a bleeder?

A. W. C.

A bleeder, or a bleeder connection, is a connection from a steam pipe or other vessel for drawing off water of condensation. Many apply the name to only such connections as draw off water when a valve or trap is opened by hand, and give the name "relief" to any automatic draining arrangement.

Feeding Water Hotter than 212 Deg.—Will a pump deliver water into a boiler at above 212 deg. F. If so, how much?

D. W. G.

A pump will discharge water into a boiler at 212 deg. F., or any higher temperature, if the water is supplied to the pump under a pressure corresponding to the temperature. Otherwise, vapor will form in the pump cylinder, preventing the cylinder from becoming completely filled with water.

Cylinder Counterbore—What purpose does the counterbore in the ends of a cylinder serve?

W. E. S.

The counterbore prevents a shoulder or rounded end being worn where the rings stop rubbing when the piston reverses its stroke. With the counterbore, part of the ring "wipes over," so that the actual rubbing surface of the cylinder wears uniformly lengthwise.

Power to Compress Air—Which will take the more power, to compress a given amount of air to a given pressure isothermally or adiabatically?

A. E. J.

More power will be required to compress it adiabatically as may be seen by reference to the diagram given on page 507 of the Oct. 1, 1912 issue. The area of the isothermal diagram, and hence the amount of work, is less than that of either the actual compression or the adiabatic diagram.

Ventilating a Boiler Room—How can the gases and fumes from a boiler room, where a low grade of culm is burned, be removed? A roof ventilator seems to be ineffective; why is it?

W. S. C.

If there are not doors or windows on opposite sides of the room which can be opened to create cross-current ventilation, it will be well to install an exhaust fan near the floor. Overhead ventilation is ineffective because the gases, as they cool, settle, being heavier than the surrounding atmosphere.

Removing Oil from Belting—How can oil be removed from leather belting?

A. C. H.

No solution or wash should be used for removing oil from belting as it would be likely to loosen the cemented joints. It is safer to apply a powder such as whiting, fuller's earth or carbonate of magnesia to take up the oil. Afterward the oil may be washed out of the powder with a strong alkaline solution and, after settling, the solution may be drained off and the powder dried and repulverized for future use.

Volumetric Efficiency—What is the volumetric efficiency of an air compressor and how is it obtained?

J. E. A

The volumetric efficiency is the ratio of the volume of free air actually compressed in a given time to the piston displacement in the same time. To determine it accurately, the only way is to measure the air taken in or discharged, or both, as a check, since there are several variables entering in. Approximate determinations may be made from indicator cards, as explained on pages 963 to 965 of "Experimental Engineering," by Professors R. C. Carpenter and H. Diederichs, (1912 edition).

Effect of Increased Exciting Current—Will increasing the exciting current on an alternating-current generator increase or decrease the lead of a wattless current?

E. J. R.

It will not increase or decrease the lead or lag of a wattless current. However, the voltage drop, at full load, is greater with a low-power factor, and the lower the power factor the poorer the voltage regulation in an alternating-current machine. From this it will be seen that with a low-power factor, the field current of the machine must be increased to carry the load at the required voltage. However, the regulation of the field current has no direct effect upon the power factor. This is governed entirely by the character of the load. If synchronous motors form part of the load, by regulating the field current of the motor, it may be made to take a larger leading wattless component, and thereby raise the power factor of the system.

Dutch-Oven Furnace—Where did the Dutch-oven furnace originate? What kind of fuel is used in it? Is it economical in the use of fuel? Does not a furnace directly under a boiler give better results where wood and refuse are burned?

E. G. H.

The "Dutch-oven" type is a very old form of furnace used for heating long cylindrical boilers, laid down close to the ground with very low side walls and frequently a long ditch-like passage for conveying the products of combustion beneath the boiler. Some of the earliest of these furnaces so used were employed by blast furnaces in the United States, burning coal or wood and later waste blast-furnace gases.

Properly designed and proportioned, a Dutch-oven furnace can be operated more economically than a furnace placed under one end of a boiler. The waste of heat by radiation from the roof is usually more than offset by the more complete combustion not so generally attainable in an ordinary furnace wherein the gases are too soon chilled by the boiler surfaces. This applies regardless of the fuel used.

Horsepower of Tubular Boiler—What is the horsepower of a return-tubular boiler having a shell 4 ft. in diameter, 18 ft. long with 24 four-inch tubes?

W. L. K.

The usual rating of such a boiler is based on 10 sq.ft. of heating surface per boiler horsepower. The rule for finding the heating surface is to add one-half the area of the shell, the internal area of all the tubes and the area of one head minus twice the area of one end of all the tubes. In this case one-half the area of the shell is

$$\frac{3.1416 \times 4 \times 18}{2} = 113.1 \text{ sq.ft.}$$

The internal diameter of a 4-in. tube being 3.732 in., the internal area of the tubes is

$$\frac{3.1416 \times 3.732 \times 18 \times 24}{12} = 422.06 \text{ sq.ft.}$$

The area of one head is

$$4 \times 4 \times 0.7854 = 12.57 \text{ sq.ft.}$$

Twice the area of one end of all the tubes is

$$\frac{2 \times 4 \times 4 \times 0.7854 \times 24}{144} = 4.19 \text{ sq.ft.}$$

The total heating surface, therefore, is

$$113.1 + 422.06 + 12.57 - 4.19 = 543.54 \text{ sq.ft.,}$$

and the horsepower, according to the above rating

$$\frac{543.54}{10} = 54.35 \text{ hp.}$$

The total horsepower which can be got out of the boiler will exceed this, for it is limited only by the amount of heat that can be put into the boiler. All boilers can be forced considerably beyond their normal rating.

ENGINEERS' STUDY COURSE

Mensuration—Part VI

Spheres

A sphere, Fig. 1, is a solid having a curved surface all points on which are equally distant from a point within called the center.

A very easily remembered formula for the area of the surface of a sphere is

$$A = 4 \pi r^2$$

where

r = Radius;

$\pi = 3.1416$.

When it is remembered that the area of a circle is equal to πr^2, it will be seen that the area of a sphere is four times the area of its cross-section through the center. For a mental picture, to fix the fact in the mind, imagine an orange quartered by two cuts at right angles; then the area of the skin surface of the quarter section will exactly equal the sum of the areas of the cut surfaces.

To prove the formula for a sphere's surface, suppose a section of a sphere, similar to the quarter orange section to be cut as shown in perspective in Fig. 2. It is now an eighth of a sphere, but for the purpose of our proof, we will slice off a little more, as indicated, until the distance around the circumference is just equal to the radius r.

In Fig. 2 this piece of a sphere is also shown as in a working drawing—three views—one directly toward the curved surface (which by the way is called a spherical

Fig. 1.

triangle), as the piece stands on its flat base, one a view looking directly down on it, and one a sectional side view. The distance ABC is the actual altitude of the spherical triangle. Let this be divided into equal parts, and the object sliced as indicated by the horizontal lines. By construction, the base of the triangle was made equal to r, therefore, any other of the horizontal curved lines as r' will be equal in length when straightened out to the corresponding horizontal lines in the right view, which lines, it will be observed, grow gradually shorter and closer together going from the bottom to the top.

Presuming these slices to have been made very thin, instead of as drawn, and the area of one at the bottom, as *abcda*, would be equal to the height as measured along the curved altitude multiplied by the radius and its equivalent flat area would be found at $AefgA$ in the right view. But, proceeding upward, this is no longer true. For example, at r', the unit altitude is still the same for the actual area, but in the right view is becoming shorter; hence, to show true area, we should have to draw a new figure as *hijkh*, in which hk is equal to hl or r'. Suppose we draw a perpendicular from i to the line hl, as im. As

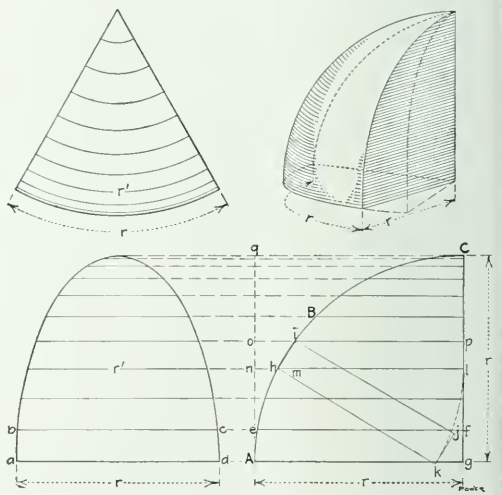


Fig. 2.

can be seen by inspection, im is shorter than hi and, if we wanted to construct a rectangle equal in area to *hijkh*, with the altitude equal to im, it would have to have a base longer than hk. By actual measurement, we would find that it must be nl, which proves to be equal to r, and the area *nopln*, being made equal to the area *hijkh*, also equals the corresponding curved area having r' as its base.

So it might be shown for any other small area slice clear to the top and the sum of all these areas will be the spherical triangle in the one case and the square $AqCgA$ in the other, which must, therefore, be equal.

The area of the square we know is $r \times r = r^2$, then the area of our triangle is r^2 and it remains only to discover what part this spherical triangle is of the sphere's total surface.

Since the base equals r, to complete a half sphere made of such pieces would take as many pieces as r is contained in the circumference, or

$$\frac{2 \pi r}{r} = 2 \pi \text{ pieces}$$

To make a whole sphere, would require twice as many

or $4\ \pi$ pieces, and each piece being of area r^2, the whole sphere's area is $4\ \pi\ r^2$, as was to be proved.

Another interesting thing that is true of the area of a sphere is that it is exactly equal to the convex area of a cylinder that will just contain it, as in Fig. 3. (By convex area it will be remembered is meant the curved area of the cylinder or the total area minus the areas of the two circular ends.)

Let us see why the above statement is true. We have seen that the area of a sphere equals four times the area of a circle formed when the sphere is cut through its center (such a circle is known as a *great circle*). Expressed as a formula, this was,

$$A = 4\ \pi\ r^2$$

Suppose we divide this by the diameter, D, or, what is the same thing, twice the radius, $2r$, we then have

$$\frac{4\ \pi\ r^2}{2\ r} = 2\ \pi\ r$$

but, as we learned before, $2\ \pi\ r$ equals the circumference of a circle of radius r, i.e., a great circle.

Then another way to find the surface of a sphere is to multiply its diameter by the circumference of its great circle. To find the convex area of a cylinder, as explained in an earlier lesson, we would multiply its height by its circumference. But by inspection of Fig. 3, we will see that the cylinder's height, in this case, equals the diameter of the sphere and its circumference the circumference of a great circle of the sphere, so we find that the two areas are equal, just as was stated.

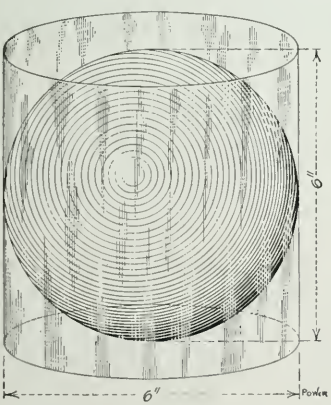


Fig. 3.

Example: What will be the area of a sphere 22 in. in diameter?

The radius will be half the diameter, or 11 in. So, substituting in the formula, we have

$$A = 4 \times 3.1416 \times 11^2 = 1520.53\ in.$$ Ans.

If a sphere were cut into several very thin slices, the largest slice, that which would be a section through the center, would be its *great circle*. We see from this that the circumference of a sphere equals the circumference of its great circle.

If a sphere is cut in half, we have two *hemispheres*, which are also *single-base segments* of a sphere. The hemisphere at the bottom and the segment at the top of Fig. 4 are single-base spherical segments. The middle part of Fig. 4 is a *spherical segment of two bases;* this form is also called a *zone* of a sphere. The *altitude* of a spherical segment is the height of the segment or the greatest perpendicular distance between its bases. The radius of the base of a spherical segment is half of the diameter of the base which is a circle; the radius of the upper base of a single-base spherical segment is zero.

Rule: *The surface of a spherical zone, or segment, equals its altitude times the circumference of the great circle of its sphere.*

Or, stated as a formula,

$$A = 2\ \pi\ r\ h$$

where

r = Radius of the sphere;
h = Height or altitude.

The proof of the statement is evident at once from the demonstration given before of the surface of a sphere. Then, each of the unit areas considered was a part of a zone (a $\frac{1}{2\ \pi}$ part) and it was shown that each of these areas equalled one having a base r multiplied by an altitude that is the same as the zone altitude. These areas, therefore, each equalled $r \times h$ and since they were $\frac{1}{2\ \pi}$ parts of zones, a full zone would be $2\ \pi \times r\ h$, as was to be proved.

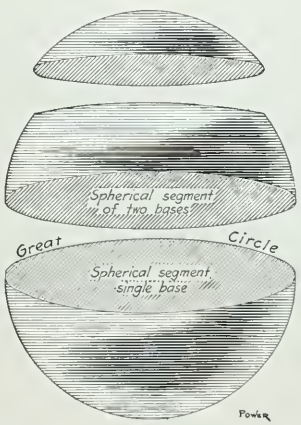


Fig. 4

Example: A sphere with a radius of 4 ft. is cut by two parallel planes, one through the center, the other 2 ft. above the center, forming a zone or spherical segment of two bases. What will be the area of the zone?

The circumference of the great circle of the sphere from which the zone is cut will be the circumference of the base of the zone (because it is a great circle). This times the altitude of the zone gives the area, or

$$2 \times 3.1416 \times 4 \times 2 = 50.2656\ ft.$$ Ans.

Rule: *The volume of a sphere equals the area of the surface multiplied by one-third of the radius.* Stated as a formula, we have,

$$V = \tfrac{1}{3}\ Sr$$

where

S = Surface area;
r = Radius.

This is very easily proved from knowledge we already have. It depends only on the fact that the volume of a

pyramid is equal to the area of the base multiplied by one-third of its altitude. Just imagine a sphere made up of a very large number of pyramids, all of the same altitude, with their apexes all at the same point (the center of the sphere). The bases of the pyramids would then form roughly the surface of a sphere, and perfectly so if the pyramids all had small enough bases.

The volume of a group of pyramids, all of the same altitude, would be equal to the sum of their base areas multiplied by one-third of the altitude. And there you are, for that is just what a sphere is, only we call the sum of the bases, the surface, and the altitude, the radius.

Substituting the equation for the surface as previously derived

$$S = 4 \pi r^2$$

in the volume equation gives

$$V = \tfrac{1}{3} \times 4 \pi r^2 \times r = \tfrac{4}{3} \pi r^3 = 4.1888 r^3$$

Or, in terms of diameter instead of radius (r being equal to $\frac{d}{2}$)

$$V = \tfrac{1}{3} \pi \left(\frac{d}{2}\right)^3 = 0.5236\, d^3$$

Example: Find the weight of a cast-iron ball, 15 in. in diameter, cast iron weighing 0.26 lb. per cu.in.

Applying the last formula for volume,

$V = 0.5236 \times 15 \times 15 \times 15 = 1767.15$ *cu.in.*

and the weight will be

$1767.15 \times 0.26 = 459.459$ *lb.* Ans.

ANSWERS TO LAST WEEK'S PROBLEMS

(1) 898.56 lb.

(2) (a) 1304.29 gal.

(b) 4.656 ft., closely 4 ft. 8 in.

(3) 8.89 loads.

(4) The slant height of the housing is 11.045 ft. As the housing has no flooring and nothing is allowed for waste, 530.16 linear feet will be necessary.

California Engineers Seek State Regulation

The steam engineers in California are taking active steps toward improving their standing by securing state regulation of their work. Recently a meeting was held in the Pacific Building, in San Francisco, which was attended by delegates from 30 organizations of steam engineers for the purpose of considering a proposed state license for the craft.

A special committee appointed to look into the matter submitted a draft of the proposed law, which was approved by all the delegates present. This measure will be submitted to the coming session of the legislature which will meet in Sacramento the early part of this year. It provides for the examination and licensing of all engaged in steam engineering by a board of three examiners, to be appointed by the governor.

A vigorous campaign will be conducted at Sacramento in support of this measure when it is presented for the action of the legislature. Nothing is being left undone by those interested in this movement to secure its early passage. With the assistance that is being solicited of the central labor bodies as well as the employers' associations, there is good reason to believe that the outcome will be successful.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

At this writing, President Taft has become a professor and Professor Wilson the President. All the excited populace is hip-hipping and the enthusiastic press hur-hurrahing; everybody loves his neighbor, the good times are here, and the goose hangs high, all because Bill steps down and out and Woody steps up and in. But, tomorrow! Then begins the tinkle of the anvil chorus. The populace and the press take their respective corners, time is called, the battle is on, and the slugging begins. At least, this has always happened after other presidential elections. In the meantime—"John Henry, if you're goin' to work today, you'd better get up!"

George F. Paul, in the February "Edison Monthly," contends that—

> The whale that bolted Jonah down
> Was kept awake o' nights
> By hearing Jonah's frantic cry,
> "Turn on the 'lectric lights!"

Nay, nay, friend Paul, the "shut-down" must have really taken place when—

> The whale that bolted Jonah
> (Thereby gaining wide renown)
> Threw off his "load" as Jonah said:
> "You can't keep good men down!"

We will stand for the boozoriums being called "power houses" and their output "shocks" and "third rails," but we'll rear on our hind legs if the lunch counters ever adopt the "2000-volt" snack. They may feed invalids this dose in that gay Paris—a newspaper says so. We refuse to mix our business with our pleasure.

Our government has given the tomato first place in the vegetable kingdom "because it can be prepared in a greater number of ways." We once questioned the preparedness of a luscious, blood-red tomato coming our way, just bursting with enthusiasm and over-development. When our alabaster brow had bisected its line of travel, we changed our mind (and our habiliments). Hail to King Tomato; it's all to the catchup when bottled up!

Of the countless words written in eulogy of the Father of our Country, we like best Artemus Ward's epigram: "G. Washington never slopped over." Which thought impels us to the belief that this Do-it-now thing should give place to the slogan "Never slop over!" Do-it-now has been taken too literally by people who are always doing the wrong thing—and by absconding cashiers.

The United States Supreme Court is asked to decide the question, When is an orange ripe? Having solved this problem, we would ask, When is an egg, and why? We have every respect for a young and tender egg, but once its youth has fled and it evinces strong signs of the decay of old age—well, some court of last resort should come to our assistance.

Surely the foreword page, "Engineers of Tomorrow," in this issue, must bring to mind your boyhood. Those were the days when mother's empty flour barrels disappeared: Dad "cussed" because he could not find one crooked, rusty nail to mend the hencoop, and the family hammer and the bucksaw were left in the yard over night to rust in the dew; the ax got an inch "nick" in it trying to cut a nail; the new bundle of shingles for that leak in the roof, and the laths, were gone; those barrel-hoops for the tomato plants; the parlor-stove pipe, the lantern that illumined the path to the barn, the screwdriver to hang the screen door, the monkey-wrench, the— Why, Jimmy, you and me and the Wilkins boys were building an engine! And it all helped afterward, for Tommy Wilkins is today pulling out the fast freight on the X., Y. & Z.; Hen Wilkins is building real engines, and you and me—well, we're "engineers of today."

Collapse of Fourteen-foot Flume

SYNOPSIS—Shortly after water had filled the pipe the flume collapsed for 1000 ft. of its length. Probable cause, unbalanced air pressure.

On Feb. 18, a new 14-ft. steel flume of the Balleville Hydro-electric Co., located at Balleville, Ohio, which is about three miles from Fremont, partially collapsed for 1000 ft. of its length. The flume, which was laid on the west bank of the Sandusky River, rested on a double row of concrete piers fitted with saddle caps. It was designed to carry the water from the dam to the power house, some 3000 ft. distant, under a head of 30 to 40 ft. The power plant was equipped to generate 6000 kw., which had been contracted for by the Lake Shore Electric Co.

The accompanying drawing shows the design of the joint.

The photographs show what happened to the flume. In Fig. 1, the crosses indicate the limits between which the collapse occurred. The maximum drop was about 6 ft. In Fig. 2, the fishplates have been removed and the breaks in the angles near the joints are evident. Fig 3 shows how the vertical legs of the angles buckled at the top of the flume.

No data, giving the grades of the flume along its length, are available but from the photographs it would appear that the run is practically straight with a uniform drop toward the plant. Evidently the cause of the collapse was unbalanced air pressure between the interior

FIG. 1. COLLAPSE OF THE FLUME OCCURRED BETWEEN THE CROSSES

FIG. 2. FISHPLATES REMOVED, SHOWING BREAKS IN STIFFENING ANGLES

Water was turned into the flume for the first time on Feb. 18, and shortly after the flume had filled, the collapse occurred, starting at a point about 250 ft. below the head gate at the dam. Following are some details of construction:

FIG. 3. VERTICAL LEGS OF ANGLES BUCKLED AT TOP OF PIPE

The thickness of the sheet is $\frac{5}{16}$ in., with girth seams 6 ft. 8½ in. apart. The rivets have a diameter of $\frac{5}{8}$ in. on 2½-in. pitch. Stiffening angles 6x4x$\frac{3}{8}$ in., on 4-ft. centers, had been placed around the pipe. These were tied together at the horizontal diameter with fishplates, 15 in. long and drilled for ¾-in. rivets on a 2⅝-in. pitch.

and outside of the pipe. With a space in the upper portion of the pipe not filled with water, from some cause not evident from the meager data supplied, a vacuum might be formed so that a difference in pressure could exist. Only a few pounds per square inch would be sufficient

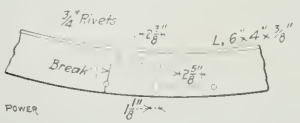


FIG. 4. CONSTRUCTION OF ANGLE JOINT

to cause the accident. Collapse of steel conduits of one-third the diameter, from a difference in air pressure, is not uncommon. As a case in point, might be cited the accidents which occurred in 1911 while testing Bull Run conduit No. 2, then being laid to provide an additional supply of water for Portland, Ore. The line consisted of 21 miles of 52- and 44-in. pipe laid parallel for the most part. In the field, it was common to lay off 4000 to 10,000 ft. of the pipeline, "dead end" both ends of the section and fill it with water. A small pump supplied with steam from a portable boiler raised the pressure to the desired point. In several cases, a rupture of the line occurred from excessive pressure. This allowed the water to discharge at a rapid rate and the upper extremity, in each case, collapsed from external air pressure.

The pipeline at Balleville is 168 in. in diameter and, per lineal inch, would present considerably more surface

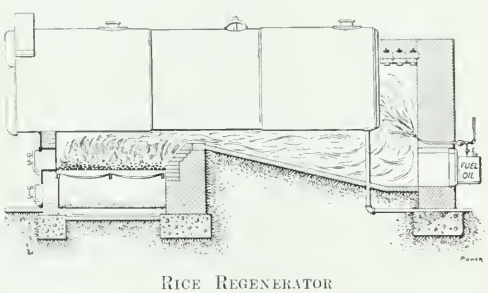
than the Bull Run conduit. It is quite probable that when the pipe was flowing full a leak may have suddenly developed at the low point of the line. For the time being there would be a solid body of water filling the pipe in the vicinity of the leak, while there would be a partial vacuum at the high point of the pipe. At this instant, the excess pressure of the external air would cause the flume to collapse.

An opportunity for the accident would also be presented when the water was shut off at the supply end. Suppose the air vent near the dam had been inadvertently closed, or that its area was not great enough for a rapid emptying of the flume or, perhaps, due to the contour of the pipeline, it was effective only for a short distance along the run, the pressure within the pipe could be less than atmospheric a sufficient amount to cause the collapse.

In either case, a series of air valves opening inward, or standpipes spaced at intervals along the line, would have prevented the trouble. In the construction of the pipeline, a continuous cradle, or at least a filling between supports, rather than the piers and saddles at intervals, would have made a better support for the pipeline and would have tended to prevent leaky joints. It would have, perhaps, been better to stagger the joints on the stiffening angles, and heavier fishplates would also have helped to prevent the collapse.

Rice Regenerator

An apparatus has been invented and developed by John Rice, an engineer of Boston, Mass., which, it is claimed, will facilitate complete combustion in any power boiler by creating secondary combustion. By means of it a vaporized mixture of oxidized fuel oil is atomized and burned in the path of the gases of combustion, reheating, to the point of ignition, any gases that have escaped in imperfect combustion from the boiler furnace.



Rice Regenerator

On a return-tubular boiler the atomizing nozzle is inserted through the rear of the setting, as shown in the illustration, to produce the secondary combustion at or about the point of the first turn of the gases from the furnace, and the additional heat, furnished by the burning of the fuel oil introduced and completion of combustion of the furnace gases, is brought directly in contact with the heating surface of the tubes.

It is claimed that complete combustion is obtained and smoke eliminated, as a result of reheating the gases to the point of ignition when supplied with the necessary air, and that the deposits in or on the heating surface of the tubes are materially lessened, insuring a better average transference of heat to the boiler. Also, that the draft is increased and maintained and the necessity of using any artificial-draft apparatus is done away with. The apparatus, it is said, may be used to advantage to meet full-load or overload demands for steam. The cost of operation will depend on the conditions, but an equivalent improvement is declared to result whatever kind of fuel is used.

The device will be marketed by a new company being formed in Boston, to be known as the Rice-Watts Co.

Oil vs Coal for Fuel

In his memorandum to the Executive Committee of the Manchester Steam Users' Association, Chief Engineer C. E. Stromeyer discusses the question of the use of oil instead of coal for fuel. Consideration of the problem was suggested owing to the interests of members being affected by the national coal strike in Great Britain.

It is recalled that about three decades ago an enterprising shipowner adapted the furnaces of the boiler of one of his coasting steamers to burn Scottish shale oil. The economic results were so favorable that others started to burn this oil, but as the Scottish shale oil supply was limited prices rose to a prohibitive figure and soon all the steamers had to revert to coal. Mr. Stromeyer uses this as an illustration to show that if American and Russian oils were suddenly to be largely used instead of coal, a similar condition of things would arise. His conclusion is that the general use of oil is out of the question in countries which are rich in coal, except under exceptional conditions, such as a national coal strike.

Recognizing that coal varies from less than $2.50 for slack near the colliery to well over $5 for good coal in towns, Mr. Stromeyer admits the difficulty in making a comparison of prices, but submits Table 1 giving the relative prices of oil and coal if equal economical results are to be obtained.

TABLE I. RELATIVE PRICES OF COAL AND OIL

Crude oil per ton, dollars	8.75	10.00	11.25	12.50	13.75	15.00
Crude oil per gallon, cents	3.5	4.0	4.5	5.0	5.5	6.0
Good coal per ton, dollars	6.50	7.50	8.50	9.50	10.25	11.25

At briefly stated in a covering letter with the ruling prices for crude oil at say 5c. per gal., the price of coal would have to rise to $9.50 per ton before the two fuels would be equally expensive to burn. The case is different when the oil is not used for raising steam but for generating power in internal combustion engines; then if the price of crude oil be again taken at 5c. per gal. it would be profitable to use this oil should the price of good coal exceed $3.75.

Mr. Stromeyer expresses the view that even if the prices of coal and oil should come into harmony, the latter fuel is not as advantageous as would at first sight appear. He says that with suitable sprayers the thermal efficiency is doubtless relatively high, but at best this will allow of a gain of only about 5 per cent., and against this has to be set the disadvantage that high efficiencies are associated with high furnace temperatures and also with such boiler troubles as bulges, grooves, etc., especially if the boiler water is at all sedimentary or greasy. Oil firing advantages are the ease with which it can be regulated and the absence of ashes and clinker, but oil must be burnt in brick-lined combustion chambers, which suffer from the intense heat and have to be frequently repaired and renewed.

To show that where steam engines can be replaced by internal combustion engines a different economic comparison results, Mr. Stromeyer gives the following particulars:

Roughly stated, a first-class modern steam engine utilizes about 12 per cent. of the available heat in the coal, resulting in say 1.6 to 1.7 lb. of fuel per b.hp.-hr. during a week's work of 55 hr. If the boilers are to be fired by producer gas, for which purpose slack and dust can be used, then each brake horsepower will require about 2 to 2.2 lb. of coal. Internally fired gas and oil engines are approximately twice as efficient as steam engines, which means that they utilize about 25 per cent. of the available heat. Crude oil being 37 per cent. better than good ordinary coal, oil engines should use only about three-eighths of the quantities of coal mentioned above, say about 0.6 lb. per b.hp.-hr. Then, however, as there are no boiler radiation losses over night a material saving results and the oil consumption per week of 55 hr. may be about 0.5 lb. per b.hp.-hr. Petrol and similar internal combustion engines would require about 0.4 lb. per b.hp.-hr. Gas engines have also about the same efficiency as oil engines; but as there is a loss of about 20 per cent. in the producers, if these work day and night, and another loss of quite 10 per cent. if they have to stand idle overnight, the efficiency of gas engines is only about 40 per cent. better than that of first-class steam engines.

Table 2 shows the relation of prices per ton (to secure equal economy) of oil and coal for various engines.

TABLE 2. RELATIVE PRICES OF COAL AND OIL FOR VARIOUS ENGINES

Crude oil for Diesel engine	$8 75	$10 00	$11 25	$12 50	$13.75	$15.00
Petrol for Diesel engine.	11.00	12.50	14.00	15.50	17.25	18 75
Coal for producer gas engine	2 88	3 38	3.75	4 13	4 63	5.00
Coal for gas fired boiler	2 12	2.38	2.62	3 00	3 25	3.50
Coal for steam engine	2 50	3 00	3.38	3 75	4 15	4 50

In further discussion of the problem the appended extract from the memorandum may be of interest. It ought to be profitable to work internal combustion gas engines, for although gas producers can be fed with very cheap fuel, the above list shows a profit even when paying 15 per cent. more than for steam coal. The reason why these engines are not used as much as might be expected, is that they are not self-contained like oil engines, but are hampered with costly and troublesome gas producers. To reduce this nuisance, gas might be produced at central stations and supplied through pipes to gas engines at the works; but that means that factories would have to be clustered together, which is against the present tendency and permits for large pipes would have to be obtained.

One additional reason against gas engines, and it applies equally to all internal combustion engines, is their liability to give trouble. This is due partly to the very high temperatures of the ignited oil or gas mixtures, which result in very serious difficulties, more particularly in large engines; serious troubles are also traceable to the severe and sudden shocks associated with gas and oil explosions. They caused trouble enough in small petrol engines, and are so serious in larger engines that certain dimensions cannot as yet be exceeded, which means that large powers can only be obtained by a large number of cylinders.

No mention has been made of electricity, for it is not a primary power but merely a transmitter of power, which means that steam engines, gas or oil engines or water where this is available, would still have to be used. Electricity has the advantage that it can be transmitted over long distances through small wires, so that if power could be cheaply produced it would be better to convert this into electricity for distribution than to distribute the gas in large mains to the surrounding factories.

However, for different purposes, heat is required in factories, and if one boiler is required it may as well be made large enough to drive the engine or be associated with one or more boilers which can all be worked by one stoker.

Pratt Institute Exhibit of Evening Work

The annual exhibit of the work of the evening classes in Pratt Institute, Brooklyn, was held on Monday evening, Mar. 17, from 8 to 10 o'clock, and was open to the public. The exhibit reflected great credit upon both instructors and students and was most successful. It included the work of both men and women in drawing and design, applied art, applied science, sewing, dressmaking, millinery, household arts and various mechanical trades, and afforded visitors an opportunity not only of viewing the work of the students in the various courses, but also of inspecting both the results and methods as well as the equipment and general facilities of the school for conducting this kind of industrial training.

The School of Science and Technology provides instruction in industrial electricity, technical chemistry, mechanical drawing and machine design, strength of materials, stationary engineering and power-plant machinery, machine work and tool making, carpentry and building, pattern making, sheet-metal work, plumbing and advanced manual training for teachers.

Recovery of Coke from Ashes

The proposition to recover the combustible remaining in coal ashes, which has so frequently attracted attention of economists, is receiving earnest attention in Germany where it is said 150 million tons of coal are burned annually and about one-third of that amount is burned in furnaces from which the ash and cinder would yield 6 to 8 million tons of residual matter containing 2 to 3 million tons of combustible material. A mechanical process for separating the combustible matter from ordinary boiler and household ashes has been designed by Adolph F. Muller.

An experimental plant is said to recover 38 tons of coke ½ to 2 in. in size from 2000 tons of ordinary boiler ashes. Calorific tests have shown that this recovered material, when dry, contains about 84 per cent. combustible matter and has a thermal value of about 6500 B.t.u. per lb. The process consists in first crushing the ashes and then separating the ingredients, by placing them in liquids of different specific gravities. The slag left after the separating process is practically free from any combustible material and is found to be an excellent material for use in the manufacture of concrete blocks.

The inventor of the apparatus is engaged in erecting a commercial plant for recovery of coke and slag in one of the suburbs of Berlin.

NEW PUBLICATIONS

ALTERNATING CURRENT MACHINERY. By William Esty. Published by the American School of Correspondence, Chicago. 1912. Size, 6x10; illustrated; half leather.

The previous editions of this work, as one of the text-books of the American School of Correspondence, have become so well known and so generally used that little need be added, except that the present edition contains some 50 more pages than the former, and the text has been rearranged and partly rewritten to cover the latest practice in alternating-current work. The same method of presentation is employed and the subject is successfully handled without recourse to higher mathematics.

DIESEL ENGINES FOR LAND AND MARINE WORK. By A. P. Chalkley. Published by D. Van Nostrand Co., New York, 1912. Size, 9x5 in., 226 pages, illustrated; cloth. Price, $3, net.

During the fifteen years that the Diesel engine has been in commercial use, it has formed the topic of many articles in the technical press, and most books on internal-combustion motors have devoted more or less space to the subject; usually, however, in a very general way. The present work is the first attempt at an exclusive and complete treatment of the subject in book form.

Following an introductory chapter by Dr. Diesel, setting forth the scope of the Diesel engine, the author first takes up the general theory of heat engines with special reference to the Diesel type and then explains in an elementary manner the working of this type. Constructive details are next taken up, in which connection the principal makes are described and illustrated.

A particularly instructive chapter is that which deals with the installing and running of Diesel engines. This is followed by a chapter on testing, which contains much useful data on the performance of these engines.

The marine type receives considerable attention and the problem of reversing arrangements is dealt with at some length.

The subject is handled in a simple yet comprehensive manner, and the book should prove a ready reference for engineers interested in Diesel engines.

WATER: ITS PURIFICATION AND USE IN THE INDUSTRIES. By William Wallace Christie. D. Van Nostrand Co., New York City. Cloth 5½x8-in.; 79 illustrations; 3 colored plates. Price, $2.

Much of the material of this book appeared in a series of articles in "Industrial Engineering and Engineering Digest." To this the author prefaced material appropriately introductory to the subject and he has systematically linked together the leading requirements and methods of purification of water in such a manner as to make presentation of the subject sufficiently complete and comprehensive for an owner or engineer to decide upon the methods of purification and type of apparatus most suitable for treatment of water for the leading industrial purposes.

The different methods required for purification are set forth and representative apparatus is illustrated and described in each instance; and although the author refers by illustration to apparatus furnished by different manufacturers, their identity will be apparent only to those who have made a special investigation of the commercial side of the subject.

In the preface it is stated that the description of each manufactured apparatus referred to has had the approval of the maker and all information has been brought down to the present.

Following reference to the sources of waters and the impurities found in water, the author describes in detail what the impurities will do, also the properties of water required in the various industries: for example, concrete, dyeing and bleaching, tanning, ice making, laundries, etc. The laundryman will appreciate the pages which are given to the saving to be had in soap—from use of water softening apparatus. A number of analyses are given and the results obtained in purifications or treatment. Nearly all of the illustrations, which are 82 in number, including three in color, clearly show the processes referred to. The leading types of water softeners and the peculiarities of the different machines for different purposes are described. After treating cold process softening, the hot process systems are taken up, giving the chemicals used and the results obtained from these systems.

Another chapter gives the results accomplished by water softening in different parts of the country and sufficient notes of the analyses of the water to get some idea of the benefits of treatment. Pressure filters receive attention, different strainers used are illustrated and tables are given of the capacities of the machines. The purification of water by ozone is considered and reference is made to aeration, giving the nozzles used and their capacity, notice is made of methods of purification of water by sterilization and by heat, and by distillation and data given on storage of water, and losses from surface evaporation in different parts of the country.

Another chapter refers to drinking water, the cost of filtration, the results obtained, and the costs of filtration at some of the largest plants. Open gravity filter tanks are illustrated, and tables given of the size and capacity of the various filters. Purification of water for boilers is not specially considered in this book, the field being covered more thoroughly in the author's earlier book, "Boiler Waters, Scale, Corrosion and Foaming"; but in one of the chapters considerable space is devoted to the treatment of water for removing oil carried over by the engine exhaust from water to be used for boiler feeding and other purposes.

Marine practices are given and the cost of pumping water under various conditions have received attention; the author quoting figures of results obtained in different parts of the country gives the cost of pumping water under different heads and by different methods.

The last chapter gives miscellaneous tables and general information useful in hydraulic computations, including a table of chemical symbols, atomic weights, cost of water works, pipe lines, and capacity of tanks and cisterns of various sizes, and definitions of hydraulic units.

The book is of convenient size for reference, and should prove to be of value to power-plant engineers, mill owners and engineering students.

BOOKS RECEIVED

STEAM ENGINEERING. By William R. King. John Wiley & Sons. Cloth; 450 pages; 6¾x9¾ in.; illustrated. Price, $4.

ENGINEERING DIRECTORY, 1913. Crawford Publishing Co., Chicago. Leather, 1552 pages; 4½x6¾ in.; illustrated. Price, $5.

EVOLUTION OF THE INTERNAL COMBUSTION ENGINE. By Edward Butler. J. B. Lippincott Co. Cloth; 237 pages; 6x8¾ in.; illustrated. Price, $3.

ENGINEER'S HAND BOOK ON PATENTS. By William Macomber. Little, Brown & Co., Boston. Leather, 288 pages; 1¾x7¼ in.; illustrated. Price, $2.50.

THE GASOLINE ENGINE ON THE FARM. By Xeno W. Putnam. Norman W. Henley Publishing Co. Cloth; 527 pages, 5½x7½ in.; illustrated. Price, $2.50.

DESIGN AND CONSTRUCTION OF STEAM TURBINES. By Harold Medway Martin. Longmans, Green & Co. Cloth; 372 pages; 7¾x11 in.; illustrated. Price, $8.50.

STEAM BOILERS. By Edward F. Miller. John Wiley & Sons, New York. Second and third edition revised and enlarged. Cloth, 543 pages, 6x9 in.; 228 illustrations; plates; tables; indexed. Price, $4.

Conference of the Society for Electrical Development

The first general meeting of the Society for Electrical Development was held at the Engineering Societies Building, New York, on Mar. 4 and 5 for the purpose of discussing and formulating a definite plan of procedure.

This society represents the coöperative interests of central stations, electrical manufacturers, jobbers, contractors and dealers, the purpose being to promote these industries through a more extensive use of electricity. Architects and representatives of the press were also invited to join the movement.

President H. L. Doherty, in his opening address, spoke of the aims of the society and said that $100,000 had already been subscribed, but that it was hoped to raise at least $200,000 a year to carry on the work. A large sum would be expended in publicity for which purpose a publicity bureau of the society would be established. One of the chief duties of this bureau would be to keep the public informed of the great work that is being done in the application of electricity to various industries. In his opinion great opportunities lie ahead of the central station, one of these being the use of electricity on the farm. Speaking as a representative of large corporations he believed that the present sentiment toward the regulation of "big business" would be harmful.

James M. Wakeman, general manager of the society, next spoke of its aims and pointed out the need for coöperation in the commercial side of electricity. He also dwelt to some

length upon the publicity idea and also suggested that the society have a staff of trained solicitors which could be placed at the service of the smaller electric companies.

Frank H. Gale, of the General Electric Co., then read a paper on "The News Value of Electricity." He pointed out that there is an abundance of good material which would make interesting reading for the public, but that this must be got up for the benefit of the reader and not from the standpoint of the advertiser. He also urged frankness and publicity upon the part of public service corporations.

A paper on "Electricity and the Architect," by F. E. Wallis, was next read and discussed. This was followed by an address by Dr. Talcott Williams, of the School of Journalism of Columbia University. The speaker referred chiefly to the work that is now being done at Columbia toward preparing students for a journalistic career and said that a very large part of the course was devoted to the fundamentals of physics and chemistry so that the student would be able to comprehend to a cerain extent such technical matter as he might later be called upon to report.

The next speaker was T. C. Martin who, speaking on behalf of the National Electric Light Association, told of that organization's attitude toward the new society, the two having many interests in common. The central station industry, said Mr. Martin, is now doubling itself every five years and anything that the Society of Electrical Development can do to make the industry double at a more rapid rate would be of mutual interest.

J. C. McQuiston, of the Westinghouse Electric & Manufacturing Co., next read a paper on "Efficiency of Local Advertising." He referred to various forms of "display" advertising and called attention to the moving-picture machines as an excellent means of arousing the public's interest in electrical applications.

Other papers read at the session were "The Sales End," by James H. Collins; "Merchandizing Coöperation," by W. E. Robertson, of the Robertson-Cataract Co., and "An Electrical Advertising Campaign," by W. D. McJunkin, of Chicago. All the papers were freely discussed.

The conference ended with a banquet at Delmonico's on the evening of Mar 5.

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Chief Engineers Club of Detroit

A new engineering society, the Chief Engineers Club of Detroit, has been formed in that city, composed only of engineers holding a first-class city license and employing one or more licensed assistant engineers. It has on its roll most of the progressive engineers running the larger plants. The chief boiler inspector of Detroit is a member by invitation.

The club has as its object the cultivation of good-fellowship among the local chief engineers, by lectures and discussion, to increase the efficiency of its members. It will meet every month in the Wayne County Bank Building.

The officers for the ensuing year are: President, Charles Koehler, Murphy Power Co.; vice-president, Charles Mery, Fairview Pumping Station, recording secretary, Harry E. Page, Hotel St. Claire; financial secretary, Edward Hall, Public Lighting Plant; treasurer, Alexander Kothe, U. S. Frumentum Co.; marshal, Charles Gelhaar, Voigt Brewing Co.; alternate marshal, Harry Stummell Kling Brewing Co.; chairman of entertainment committee, Joseph H. Roberts, Parke-Davis Co. Charles A. Ellis, of the Chamber of Commerce Bldg., was unanimously elected to fill the office of first past-president.

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The Glenlyon Economizer Explosion

Since the account of the economizer explosion at the Glenlyon Dye Works, Saylesville, R. I., was printed in the issue of Jan. 28, a thorough investigation has been made, but without any more definite findings as to the cause. It has, however, established that the economizer was not inherently at fault, and, in justice to the manufacturer the following letter it received from the dye works is published:

In reference to the explosion at our works, which occurred on the 11th of January last, we regret to say that careful and thorough investigation has failed to establish the exact cause.

The explosion apparently occurred in one economizer, which was temporarily out of service for slight repairs, and we think that in some way sufficient water made its way into this economizer to create the pressure which caused the explosion.

We could locate no structural defect in the economizer or weakness in the castings, and feel that if we should have further use for apparatus of this kind to utilize waste heat in chimney flue, we would not hesitate to order a Green economizer for the purpose.

$1,000,000 Steam Power Plant

Announcement is made by C. E. James, of the Chattanooga & Tennessee Power Co., says the "Tradesman," that it will begin at once the construction of a $1,000,000 steam-power plant. The new plant will be operated in connection with the $8,000,000 plant now being erected at Hale's bar on the Tennessee River.

The capacity of the plant is to be 20,000 or 25,000 hp. The purpose is to guarantee to the Chattanooga & Tennessee River Power Co. the maximum capacity of its Hale's bar plant at all seasons of the year and all stages of the river. Without the steam power the expenditure of $8,000,000 at the lock and dam would be reduced to less than half at certain stages of the river, but when the extra $1,000,000 is expended, full returns on the entire investment is guaranteed for each hour of the entire year.

SOCIETY NOTES

On Thursday evening Mar. 6, Prof. Charles M. Allen lectured on "Gasoline, Its Uses and Abuses," before the Engineers Club, of Boston. The subject as treated created much general interest. Prof. Allen gave demonstrations of the explosive and non-explosive qualities of various mixtures. After the lecture refreshments were served.

The combined N. A. S. E. associations, Manhattan and Bronx, will hold their annual banquet on Thursday evening, Mar. 27, at the Broadway Central Hotel, 673 Broadway, New York City. Good speakers and entertainers are promised and the ladies are invited. Tables may be reserved for parties by applying to the chairman. Tickets may be secured from Samuel I. Schaff, Fred G. Jolley, William M. Logan, Harry Marks and Fred Feldeiman, the committee.

Arrangements have been made to hold the next convention of the Association of Edison Illuminating Companies at the Otesaga Hotel, Cooperstown, N. Y., Sept. 8 to 11. The Otesaga is charmingly situated on Otsego Lake, in the midst of the hilly country immortalized by J. Fenimore Cooper in his Leatherstocking Tales, and offers facilities of a most attractive nature for the convention. Special arrangements are being made for through railroad service and the attention of members is directed to the accessibility of this resort by automobile through the Catskill mountains. Details of transportation and automobile maps will be included in the convention circular to be issued when the program has been assembled. President Arthur Williams states that suggestions concerning subjects for papers, or upon other matters which may add to the value of the meeting, will be greatly appreciated.

PERSONALS

Charles P. Steinmetz, past-president, American Institute of Electrical Engineers, consulting engineer of the General Electric Co., Schenectady, N. Y., has been awarded an Elliott Cresson Gold Medal of the Franklin Institute of Philadelphia, "for successful application of analytical methods to the solution of problems of the first practical importance in the field of electrical engineering."

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The annual meeting of the stockholders of the Goulds Manufacturing Co. was held at Seneca Falls, N. Y., Feb. 24. No change was made in the board of directors and the following officers were reëlected: President, N. J. Gould; vice-presidents, D. V. Colby, W. D. Pomeroy, W. E. Davis, W. E. Dickey; secretary, H. S. Fredenburg, treasurer, B. R. Wells, assistant treasurer, E. W. Madden.

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A bill has been laid before the Prussian Diet for the development of water power on the upper waters of the Weser. It provides for an expenditure of $2,142,000, of which it is proposed to spend immediately only $1,190,000 on the erection of power stations at Hemfurt and Helminghausen; the remainder will subsequently be spent on the construction of a power station at Munden. It is estimated that the three stations can produce 41,000,000 kw-hr annually.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Amherst Power Co. has purchased the plant and property of the South Hadley Falls Power Co., South Hadley Falls, Mass. The new owners will construct a substation and install new equipment in the plant. Philip Cabot, Boston, Mass., is president

Bids will soon be received by W. S. Pierce, commanding colonel of the U. S. armory at Springfield, Mass., for the enlargement of the boiler house and the installation of two new boilers in the armory.

The Webster & Southbridge Gas & Electric Co., Webster, Mass., will install new boilers and a new steam turbine to double the capacity of its plant. H. S. Shaw is superintendent.

The trustees of the Webster State Hospital, Webster, Mass., has asked for an appropriation of $70,000, for the installation of a new power plant. John L. Coffin, Northboro, Mass., is chairman.

Plans are being considered by the board of water commissioners of Black River, N. Y., for the installation of a new water-works system. Charles L. Seybold is president of the board.

The Hewitt Rubber Co. is having plans prepared for the installation of a power plant in connection with its establishment at Kensington Ave. and the New York Central R.R. Belt Line, Buffalo, N. Y.

Plans are being prepared for the construction of a boiler house in connection with the plant of the Augustine Rotary Engine Co., at Elmwood Ave. and the Erie R.R., Buffalo, N. Y.

Sackett & Parke, architects, Syracuse, N. Y., are preparing plans for the construction of a power plant for the Volney Paper Co., at Fulton, N. Y.

The proposition to issue $20,000 in bonds for the improvement of the municipal electric-light plant at Ilion, N. Y., is under consideration.

The Syracuse Crucible Steel Co. of America is considering plans for the construction of a boiler house and transformer station in connection with its new steel plant which it is erecting near Halcomb mills, Syracuse, N. Y. Specifications are on file at the office of G. M. Black, general superintendent, Oliver Bldg., Pittsburgh, Penn.

The Public Service Co., Newark, N. J., will make extensions and improvements to its Plank Road electric substation, to cost about $3000. Farley Osgood, Newark, is general superintendent.

The citizens of Trenton, N. J., are considering the proposition to construct an electric-light plant to supply electricity for lighting streets and public buildings. George La Barre is city commissioner.

The city council of Reading, Penn., has appointed a committee to investigate the feasibility of installing a municipal electric-light plant.

SOUTHERN STATES

The Richmond & Henrico R.R. Co. is preparing plans for the construction of a power plant at Richmond, Va., to cost approximately $35,000. C. Simd-Bailey, Richmond, is general manager and chief engineer.

A franchise has been granted to the Williston Mfg. Co., to construct and operate an electric-light plant at Williston, Fla.

The city council of Elizabethtown, Ky., has decided to install a water-works system and filtration plant.

Bids will be received by the board of public works, until Apr. 2, for the construction of a water-works system at Madisonville, Ky. W. J. Dublin is secretary of the board.

The Kentucky Utilities Co., of Lexington, Ky., has purchased the power plant of the Middleboro Electric Light Co., Midleboro, Ky., and is planning the installation of new equipment in the plant.

Plans are being prepared by the Kentucky Southwestern Electric Ry. Co. for the construction of a power plant at Paducah, Ky., to supply electricity for its proposed 55-mile electric railway.

CENTRAL STATES

The Citizens' Gas Co., Indianapolis, Ind., has been granted permission to expand $12,972, for the improvement of its plant. Two 300-hp. boilers will be installed.

The Indianapolis Light & Heat Co., Indianapolis, Ind., is considering plans for the installation of new equipment in its power plant.

The city council of Bloomingdale, Mich., has granted a franchise to M. C. Hawk to construct and operate an electric-light plant at Bloomingdale.

An appropriation of 119,500 has been asked by the public lighting commission of Detroit, Mich., for the installation of new equipment in the municipal electric-light plant.

The city council of Hastings, Mich., is considering the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant.

The city council of Marshall, Mich., has authorized an expenditure of $1250, for the improvement of the municipal electric-light plant.

Plans are being prepared by J. Rollin Gray, engineer, Chicago, Ill., for the installation of a water-works system at Carpentersville, Ill. Estimated cost, $30,000. M. D. Baldwin is city clerk.

The construction of an electric-light plant at Decatur, Ill., is contemplated by Frank L. Suffern and associates.

The citizens of Jacksonville, Ill., will hold an election on Apr. 15, to vote on the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant. Joseph F. Brennan is commissioner of public property.

The citizens of Nokomis, Ill., are considering the proposition to install an electric-light plant.

The Central Illinois Public Service Co., of Mattoon, Ill., is making preliminary arrangements for the construction of an electric-light plant at Perry, Ill.

The village board has granted a franchise to F. T. Morrisen, of Dixon, Ill., to construct and operate an electric-light plant at Warren, Ill.

The proposition to issue $15,000 in bonds for the construction of a municipal water-works system at Palmyra, Wis., is under consideration. L. F. Agen is city clerk.

WEST OF THE MISSISSIPPI

Plans are being considered by the city council of Fontanelle, Iowa, for the construction of a municipal electric-light plant to cost $7500.

Bonds for $12,000 have been voted for the improvement of the water-works system at Lake City, Iowa. A. O. Anderson is engineer.

The citizens of Cedar Falls, Iowa, are considering the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant.

Preliminary arrangements are being made at Early, Iowa, for the construction of an electric-light plant.

The construction of an electric-light plant at Ossian, Iowa, is under consideration. Estimated cost, $8000.

The proposition to install an electric-light plant at Grove City, Minn., is under consideration.

The Central Minnesota Electric & Power Co. is preparing plans for the construction of an electric-light plant at Waverly, Minn.

The construction of an electric-light plant is included among the improvements planned by the citizens of Cimarron, Kan.

The citizens of Augusta, Kan., voted to install a municipal electric-light plant at a recent election. J. R. Switzer is city engineer.

Bonds to the amount of $6000 has been voted for the purpose of constructing a municipal electric-light plant at Blue Mound, Kan. E. T. Archer & Co., Kansas City, Mo., are engineers-in-charge.

Bids are being received by the city of Canton, Kan., for the construction of a new electric-light plant.

The construction of an electric-light plant at Douglass, Kan., is under consideration. Local business men are interested in teh project.

The installation of a new generator in the municipal electric-light plant at Topeka, Kan., to cost $3000, is under consideration.

Bonds to the amount of $20,000 were recently voted for the construction of a municipal electric-light plant at Turon, Kan.

Plans are being considered by the city oouncil of Jamestown, N. D., for the installation of an electric-light plant.

The construction of an electric-light plant at Mohall, N. D., is under consideration.

The organization of a company at Poplar, Mont., to construct and operate an electric-light plant, is being agitated. Estimated cost, $3000.

Albert C. Moore, of Joplin, Mo., has submitted a proposition to the city council of Springdale, Ark., to install an electric-light plant and water-works system.

The city council of Ellensburg, Wash., is considering plans for the improvement of the municipal electric-light plant. The installation of additional equipment is included.

The Elma Light & Power Co. has been granted a franchise to construct and operate an electric-light plant at Elma, Wash.

The citizens of Friday Harbor, Wash., are considering a bond issue for $14,000 for the installation of a municipal water-works system.

The Bryant Lumber Co. will build a new boiler house in connection with its plant at 3200 Fremont Ave., Seattle, Wash.

The capacity of the power plant of the Pacific Light & Power Co. at Wapato, Wash., will be increased by 5000 hp. D. F. McGee is chief engineer.

It is reported that bonds to the amount of $20,000 have been voted for the installation of a water-works system at Milwaukee, Ore. D. P. Matthews is village recorder.

The power plant of the Prairie Light, Power & Milling Co., Prairie City, Ore., was recently destroyed by fire. Estimated loss, $20,000. R. C. Reese is interested.

Extensive improvements to the municipal electric-light plant at Alameda, Calif., including the installation of additional equipment, are being considered. Joseph B. Kahn is superintendent of the plant.

Plans are being prepared for the construction of an electric-light plant atOreana (Lovelooks post-office), Nev.

The plant of the Elsinore Electric Light & Power Co., Elsinore, Calif., has been purchased by the Southern Sierras Power Co., San Bernardino, Calif. The new owners are planning extensive additions and improvements to the property.

The Chanslor-Canfield Midway Oil Co. has prepared plans for the construction of two boiler houses in connection with its establishment at Fellows, Calif. Estimated cost, $5000.

The Atchison, Topeka & Santa Fé R.R. Co. is planning to enlarge the capacity of its precooling and ice-making plant at San Bernardino, Calif. Estimated cost, $250,000. G. W. Harris, Los Angeles, Calif., is chief engineer.

The Producers' Mutual Dairy Association will erect a building at 12th and K Sts., San Diego, Calif., to be equipped with machinery for an ice and cold-storage plant. Estimated cost of equipment, $20,000.

The city engineer of Santa Monica, Calif., is preparing plans for the installation of a new municipal water-works system. Estimated cost, $76,000.

POWER

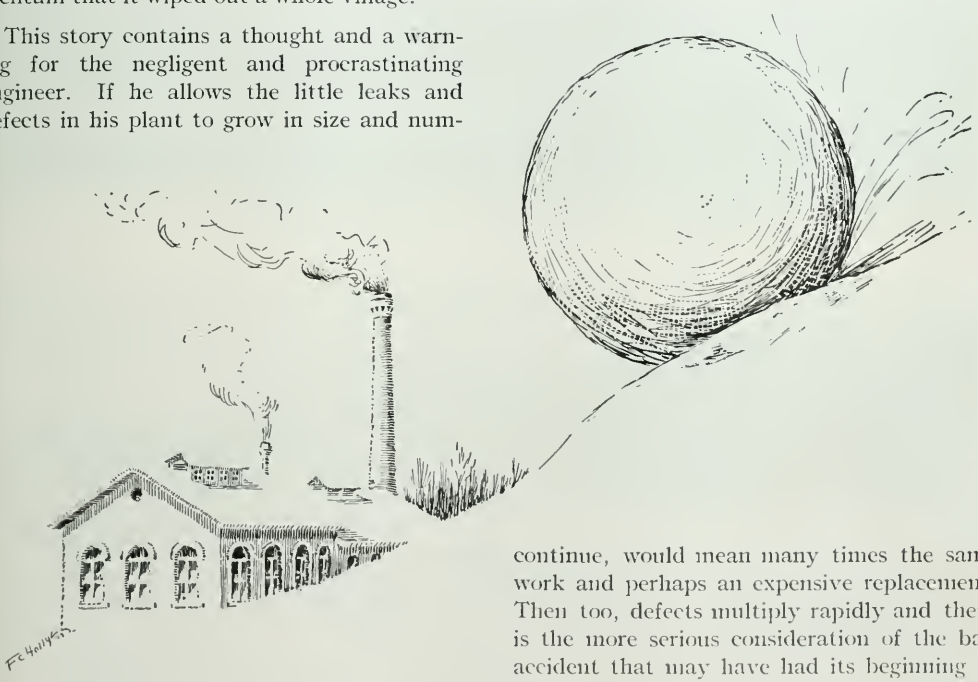
Vol. 37 NEW YORK, MARCH 25, 1913 No. 12

Negligence and Procrastination

THEY are few who have not heard the fable of the children innocently starting the snowball, which, rolling down the mountainside, attained such a size and momentum that it wiped out a whole village.

This story contains a thought and a warning for the negligent and procrastinating engineer. If he allows the little leaks and defects in his plant to grow in size and number, some day the accumulated mass will gain such magnitude as to engulf the plant, and the engineer will sit beneath the debris, as at the foot of the mountain, appalled, his energy and volition gone. From habitual disuse he will be unable to cope with the problems before him, and worse still, he will doubtless learn, when too late, that his influence with his employers is lost and that they would not trust him to spend the money needed to pull the plant out of the mire.

Often it takes but a few moments to permanently repair a defect which, if allowed to continue, would mean many times the same work and perhaps an expensive replacement. Then too, defects multiply rapidly and there is the more serious consideration of the bad accident that may have had its beginning in a comparatively small way.



Negligence and procrastination in small things culture the germ of indifference in larger and more important affairs, and the engineer who sits contentedly by and fails to attend to the little defects in his plant is paving the way for his own downfall and another's opportunity.

[*F. C. Holly, Memphis, Tenn.*]

Appalachian Hydro-Electric Development

By Warren O. Rogers

SYNOPSIS—This development will consist of five power-plant installations on the New River, Va. Two of these have been completed with a total electrical output of 29,000 hp. When the five plants are in operation the combined output will be 75,000 hp. Vertical water turbines, of the single-runner type, are directly connected to internal revolving-field alternating-current units, generating current at 13,200 volts.

Among the hydro-electric developments of the South, worthy of special notice, is that of the Appalachian Power Co. This company was organized in May, 1911, to develop the water power of the New River, Va., and distribute it by electric transmission through southwestern Virginia and southern West Virginia.

When completed, this development will consist of five dams and power houses to be known as Nos. 1, 2, 3, 4 and 5. They will all be built on the New River in Carroll and Pulaski Counties, Va. The aggregate water head will be 225 ft. and the total capacity of these plants will be 75,000 hp. Already developments Nos. 2 and 4, with a combined output of 29,600 hp., have been completed.

Development No. 2 consists of a dam, the main spillway of which is 504 ft. long and the low spillway 198 ft. long. The power house is built in one end of the dam, the overflow of which is approximately 50 ft. in height. The dam is built directly across the river. An auxiliary spillway above the power house has been constructed by cutting through a ridge and discharges into a natural sluiceway back of this ridge; this saved approximately 200 ft. of dam work. The dam is concrete and the power house brick and steel. There are five hand-operated and one motor-operated 6x30-ft. Tainter gates in the main spillway dam, and nine spans of flashboards. The low spillway dam has six spans of flashboards, which can be applied to a height of 8 ft. The total length of spillway is 702 ft. There is also a sluice duct for passing drift wood at the end of the power house. The tailrace is 400 ft. long, 90 ft. wide and has an average depth of 12 ft. Approximately 11,000 cu.yd. of excavation was made.

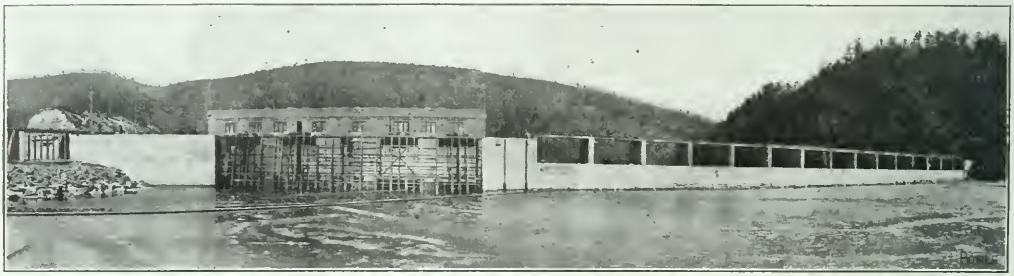


Fig. 1. View of No. 2 Plant and Spillway Dam from Above

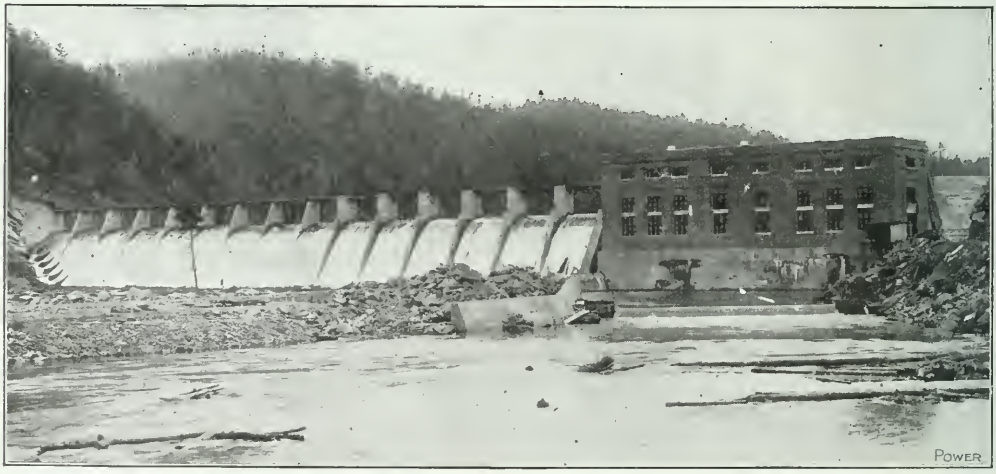


Fig. 2. No. 2 Power Plant and Spillway from Below

Power House No. 2

There are four 5000-hp. (electrical) vertical-shaft units in this power house, a view of which from above and below the dam is given in Figs. 1 and 2. The waterwheels are of the single-runner Francis type. The wheel rests

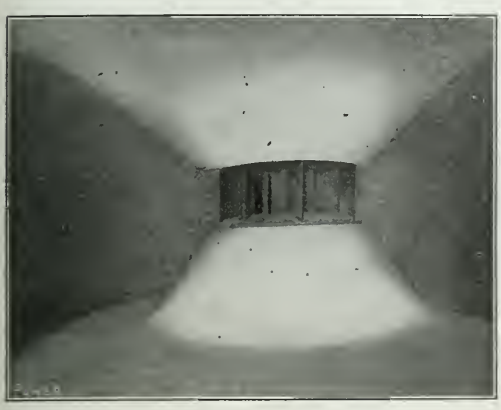


Fig. 3. Concrete Wheel Pit

on a circular concrete foundation, and water enters the wheel casing through a spiral-shaped casing formed in the concrete of the foundation. This construction is shown in Fig. 3, which is a view in the wheel pit.

These four waterwheels are coupled by vertical shafts to four 4000-kw., 13,200-volt, three-phase, 60-cycle gen-

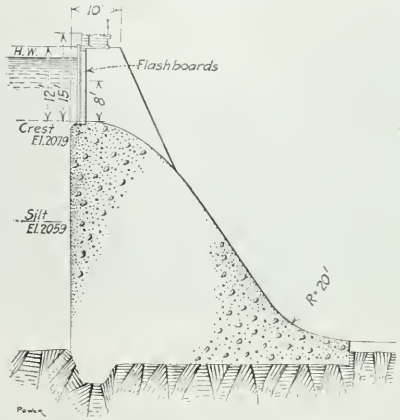


Fig. 4. Cross-section of Spillway Dam, No. 4 Development

erators of the internal revolving-field type. The speed is 116 r.p.m. The water from the wheels discharges through concrete draft tubes into the tailrace in the river bed. Water is admitted to the waterwheels through eight 14x 25-ft. motor-operated, screw-actuated sluice gates. With the flashboards in place the average head of water to the wheels is 53 ft. The Tainter gates and flashboards are for storing the water and regulating the head. By this arrangement ample water can be stored above the dam for operating the plant at any daily load factor.

Exciter Units

Between Nos. 2 and 3 generators are two water-turbine-driven exciter units. The wheels are of the inward dis-

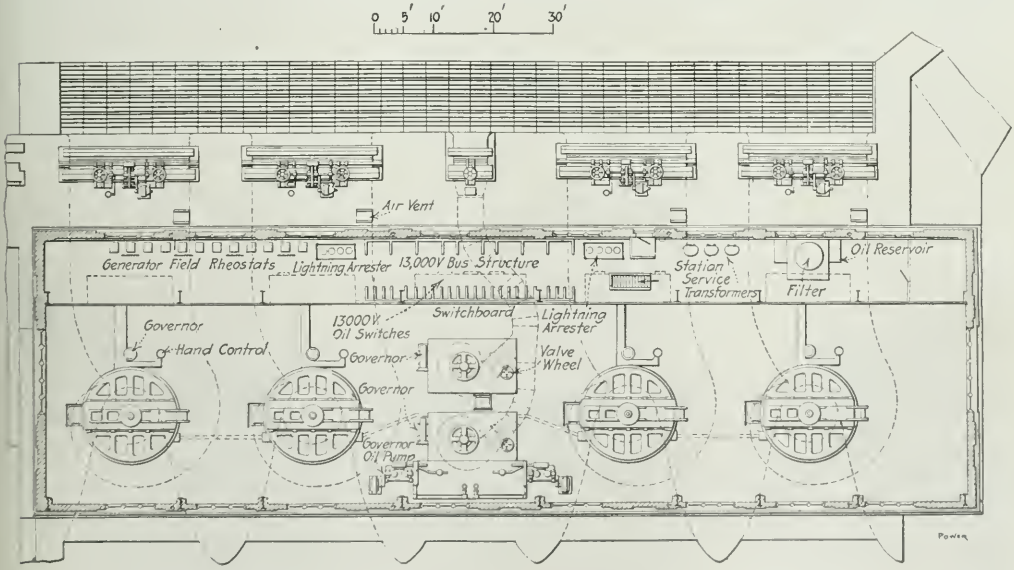


Fig. 5. Plan of No. 2 Power House

charge, single-runner type and are rated at 130 hp. each. They are set vertical and are shaft connected to two 600-amp., direct-current, 250-volt generators, running at 330 r.p.m. The speed of the units is controlled by a

Fig. 6. Panoramic View, Showing No. 4 Power Plant,

special type of oil-actuated hydraulic governor. The same type of equipment is installed in No. 4 power plant, the only difference being that in the latter plant the two exciter units are located at one end of the generator room, and are of slightly smaller capacity.

Oil Pumps

Both power houses contain two triple-plunger, motor-driven oil pumps for operating the governors. The motors are of the induction type and of 25 hp. capacity. They operate with three-phase, 60-cycle current, of 220 volts, at a speed of 845 r.p.m. The motors are gear connected to the pump crankshaft.

Air Compressors

A $7^1_4 x^3_4 x6$-in. motor-driven air compressor is at one side and at one end of each plant. The 10-hp. motor is of the induction type. It operates with three-phase, 60-cycle, 220-volt current, at a speed of 1145 r.p.m., and is gear connected. The air is used to maintain a uniform pressure of 200 lb. in the tanks of the oil system supplying the turbine governors.

No. 2 building is brick with concrete foundations. It is 162^1_2 ft. long and 89^1_2 ft. wide from the rack to the end of the draft tube. As the electrical equipment is practically the same in both plants the description of No. 2 installation will apply equally well to No. 4.

A cross-section of No. 2 spillway dam is shown in Fig. 4, and a plan view of No. 2 power house in Fig. 5.

No. 4 Development

Although No. 4 development is the smaller of the two, it is of no less interest. It is between Mountain Island in the New River and the river bank. The spillway dam is at the upper end of the island, extending from the south shore of the island to the south shore of the river; the power house is at the other end of the island and it and its dam extend from the north end of the island to the north bank of the river. The island thus forms a natural headrace to the power house.

Fig. 7. No. 4 Power Plant from above the Dam

Headrace and Spillway Dam on the New River, Va.

The spillway dam, which is built across the main channel of the river, is 1005 ft. long. It has six spans of Tainter gates and 24 spans of flashboards designed for 6½ ft. height. This dam diverts the water to the power house which, with the retaining dam, is at the lower end of this natural headrace.

Below the power house is a tailrace 1900 ft. long, 60 ft. wide and 12 ft. deep. This necessitated the removal of 66,000 cu.yd. of rock. This tailrace provides for an additional head of 15 ft., giving a total average head of 38 ft. Fig. 5 is a general plan of No. 4 development, Fig. 6 a panoramic view of the headrace, spillway dam and power plant, and Figs. 7 and 8 are views from above and below No. 4 power house. The building is a brick and steel superstructure, 126 ft. long and 34 ft. 4 in. wide, with a solid concrete foundation. The equipment comprises three 3000-hp. units, with vertical-shaft, single-runner waterwheels.

Mounted on the upper ends of the shafts of these wheels are three 2300-kw., 13,200-volt, three-phase, 60-cycle, internal-wound, revolving-field generators; the speed of each is 97 r.p.m. Fig. 9 is a cross-section of No. 4 power house. Figs. 10 and 11 are views of the generating units in plants Nos. 2 and 4.

The special type of double floating-lever governor used is operated from the generator shaft, by bevel gears and shafting. It is oil controlled, and operates a pistou and a lever connected to a rocking ring above the outer casing of the waterwheel. The rocker ring operates the arms attached to the stems of the 20 gate vanes set in the inlets of the waterwheel casing. As the speed of the wheel increases the governor closes the gate vanes enough to shut off the flow of water to the wheel and to maintain a constant speed. If the wheel tends to slow down the vanes are opened.

The exciter waterwheels have 14 gate vanes, similarly controlled. The generating and exciter units in both plants are governed in the same way. The shaft of each unit is hung on roller bearings at the top with two steadying bearings below the generator. These bearings are lubricated by a gravity-flow oil system, oil from the bearing flowing to a well and is pumped to the bearings again by a small rotary pump, belt driven from the generator shaft.

Fig. 8. No. 4 Power Plant from below the Dam

The waterwheels operate with a head of 38 ft. Water is admitted from the headrace to each wheel pit through two 14x35-ft. motor-operated, double-screw lift gates. The

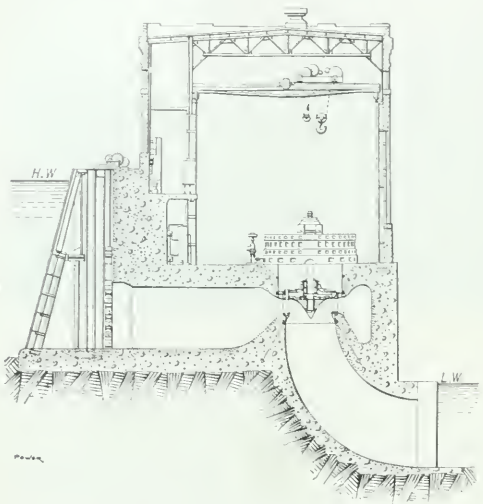


FIG. 9. CROSS-SECTION OF POWER HOUSE NO. 4

wheels set on a concrete base, the walls of which are 4 ft. thick, with a draft tube in the center.

Each generator is equipped with an indicator to show the gate opening, also a speed tachometer. In case of accident to the governor and when starting up the machines, the flow of water to the waterwheels can be controlled by hand.

ELECTRICAL CONTROL APPARATUS

In both plants the switchboard apparatus controls only the generators. The switchboards are at one side of the building. Back of them are the busbars, in concrete isolated compartments. All oil switches are remote controlled and are of 13,200 volt capacity. They are on the concrete balcony above the switchboards. The field rheostats are on the balcony, also the lightning arrester with the helical choke coils on the two No. 000, 13,200-volt

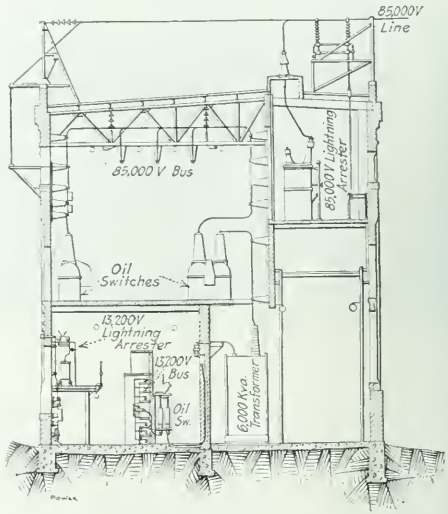


FIG. 12. SECTION THROUGH SUBSTATION

lines which extend to the transformer house near No. 2 plant.

EXCITER UNITS

Both exciter units are at the end of the generator room. Each is of 250 kw. capacity and generates 250-volt current. The waterwheels are of the inverted, single-runner Francis type, each of 250 hp. capacity. The oil pumps and air compressor are of the same design and size as those of the No. 2 development.

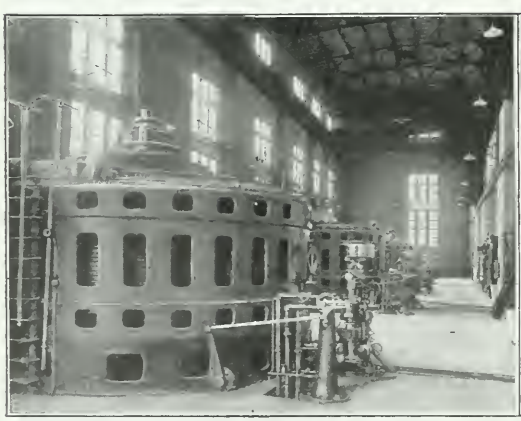


FIG. 10. NO. 2 GENERATOR UNITS

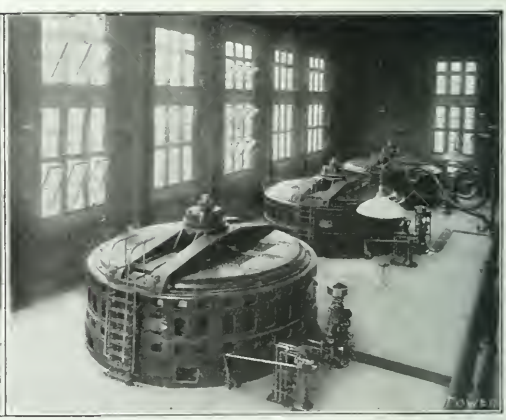


FIG. 11. NO. 4 GENERATOR UNITS

TRANSFORMER HOUSE

Electrical energy from both power plants is carried by overhead lines supported by wooden poles to the step-up transformer house adjacent to No. 2 development. A

cross-section is shown in Fig. 12. Here the electrical energy is transformed from 13,200 to 88,000 volts and distributed over the high-tension transmission system. This transformer house is designed for ultimate extension, so that all of the power from the Nos. 1, 2, 3 and 4 developments will concentrate at this house and be regulated and distributed from it. Fig. 13 illustrates the arrangement of the choke coils.

lines outgoing from the transformer house, one direct to Galax, one to Wytheville and on the same poles with the first of the higher tension lines, and one to Hiwassee, mounted on the same poles as the second of the higher tension lines.

FIG. 13. CHOKE COILS

FIG. 14. 6000-KV.-A. TRANSFORMERS

FIG. 15. SINGLE-PHASE TRANSFORMERS

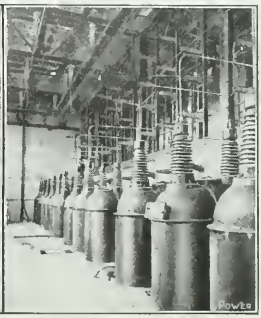


FIG. 16. OIL SWITCHES

At present there are four 6000-kw., water-cooled, three-phase transformers (Fig. 14) with 13,200-volt primaries and 88,000-volt secondaries, together with the various regulating and controlling devices, consisting of 21 oil switches, all remote control, and 12 lightning arresters on a balcony over the transformers. The busbars are in concrete isolated compartments; the transformers are on trucks and can be rolled out of their bays if it becomes necessary.

MECHANICAL EQUIPMENT OF NOS. 2 AND 4 PLANTS OF THE APPALACHIAN POWER CO.

No.	Equipment	Make	Purpose	Kw.	Volts	Amp.	Phase	Cycles	R.p.m.	Hp.	Size	Manufacturers
4	Water wheels	Francis	Main units						116	3500		I. P. Morris Co.
3									97	3000		
2			Exciter units						360	430		
2									330	250		
4	Generators	Alt. current	Main units	4000	13,200		3	60	116			General Electric Co.
3				2300	13,200		3	60	97			
2		Direct current	Exciter units	250	250	1000			360			
2				250	250	600			330			
7	Governors	Hydraulic	Main units									Lombard Governor Co.
4			Exciter units									
4	Pumps	Plunger	Oil									Deane Steam Pump Co.
4	Motors	Induction	Oil pumps		220	70	6	60	845	25		Westinghouse Electric and Mfg. Co.
2	Compressors	Motor driven	Compressed air								7½x7½x6″	Ingersoll-Rand Co.
2	Motors	Induction	Air compressors		220	26	6	60	1145	10		General Electric Co.

The low-tension, 13,200-volt inlet lines enter the house 15 ft. above the main floor; the high-tension 88,000-volt outlet lines are 59½ ft. above the floor. The transformers are delta connected on both sides. Figs. 15, 16 and 17 show oil switches, single-phase transformer, and the switchboard of the transformer station. The latter is on the ground floor.

From the transformer house there are three outgoing 88,000-volt lines. One extends to Switchback via Bluefield. The second goes direct to Roanoke, but there is a branch from this line near Pulaski going through Pulaski and on to Bluefield and Switchback. This provides a double circuit into Switchback. The third high-tension line runs direct to Saltville. There is also a high-tension line connecting the Switchback and the Coalwood substations.

In addition there are three 13,200-volt transmission

The company has a large distribution system in the Pocahontas coal fields radiating from the Switchback and the Coalwood substations. There a number of contracts have been made with collieries to provide power for their coal-mining operations. This is probably the first instance where a water-power development has supplied power to coal mines.

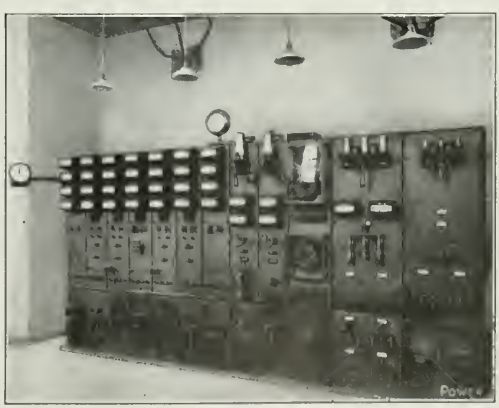


FIG. 17. SUBSTATION SWITCHBOARD

The company also operates the utilities in the towns of Marion, Wytheville, Pulaski, Bluefield, Pocahontas,

Welch and Keystone. It also sells power to the Roanoke Railway & Light Co.

In addition to the hydro-electric plants there is a 7500-hp. steam plant at Switchback, W. Va., which has been leased by the company, and will be used as a reserve station and to supplement the power from the hydraulic developments. This steam reserve will be in addition to that available from the various steam plants of the utilities purchased by the power company, and also to the steam power available from the steam plant of the Roanoke Ry. & Light Co. The map, Fig. 18, shows the water power, transmission line and district served by these hydro-electric developments.

Viele, Blackwell & Buck, of New York City, are the consulting engineers; and built the hydraulic developments and the high-tension transmission lines and substations. H. M. Byllesby & Co., of Chicago, are the engineers and managers of the company and built all the low-tension distribution system in the coal field and in the different towns which are now being supplied by the company.

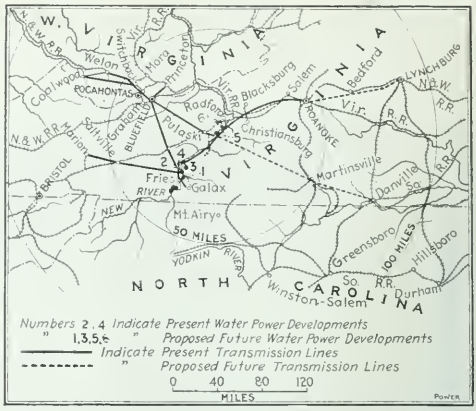


FIG. 18. MAP SHOWING POWER PLANTS, TRANSMISSION LINES AND DISTRICTS SERVED

How Many Boilers to Operate

By G. B. Mulloy*

SYNOPSIS—When the rate of feed is known, the chart gives the number of boilers to be operated at full rating as desired.

In Armour & Co.'s Chicago plant, at the Union Stock Yards, the steam for power and factory purposes is generated by thirty-two 375-hp. Wickes vertical boilers. A three-stage Allis-Chalmers centrifugal pump, having a rated capacity of 1200 gal. per min. and direct-connected to a Kerr turbine discharges the feed water through an 8x4-in. extra-heavy Venturi tube. The flow through the latter is registered by a type "M" indicator and recorder.

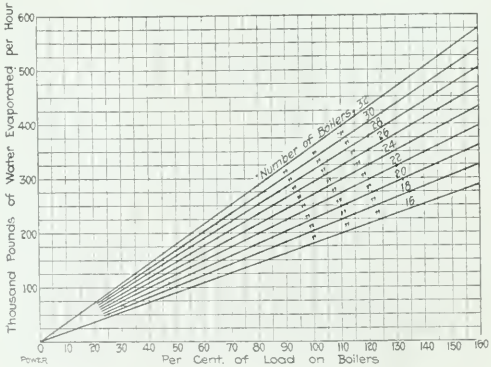


CHART SHOWING NUMBER OF BOILERS TO OPERATE

The fact that this instrument is arranged to indicate instantaneous flow as well as graphically record the fluctuations in the load carried throughout the 24 hr. makes it a desirable form of meter.

Due to the absence of any mechanism or projection within the Venturi tube the flow of water is unobstructed and this is desirable in any method of boiler feeding. From a curve which is supplied with each meter a correction factor enables the observer to determine the correct flow throughout a wide range of temperatures.

Not long after the installation of the meter the value of the data yielded was better recognized and extensive use was made of it. Previously there had existed no means of accurately determining just how many boilers were required to carry the load or within what per cent. of rating the boilers singly or collectively were working. Under ordinary conditions there is a certain load with which the best results are obtained from any given boiler and when it so happens that the steam for a given plant is generated by a battery of the same design, rating and furnace setting, only enough boilers should be in service at any one time to handle the load in the most efficient manner.

For this reason the chart herewith shown was developed, the interpretation of which is as follows: The ordinates represent pounds of water evaporated per hour, the abscissas the per cent. of normal rating developed and the diagonal lines the number of boilers required to satisfy the above variables. Assuming from a series of tests made on the test boiler that 20 per cent. overload is the most efficient operating load, the chart shows that for a flow of 300,000 lb. per hr., as indicated by the meter, 22 boilers are required. For normal rating 27 boilers would be needed or if the entire 32 boilers were used they would develop 83.5 per cent. of their rated capacity, assuming, of course, that each boiler was doing its share of the work.

So simple is the chart that it indicates at a glance at just what rating the boilers, considered as a unit, are operating, when the number in service and the rate of feed are known. It may be assumed without question that the results developed with the test boiler are generally never

*Engineer of tests for Armour & Co.

attained with each and every boiler in any one plant. The firemen naturally will show to their best advantage while on "dress parade." What they do as a regular thing in their ordinary task of firing is another story. But, by keeping a close watch on the coal pile, conditions of fires, etc., and constantly using the accompanying chart, it is possible to operate any boiler equipment so as to come within a close fraction of test conditions. Operating with the correct number of boilers for any given load will help to reduce to the minimum the cost of generating a unit quantity of steam, because the lower such items as labor, furnace and boiler repairs, radiation, loss of fuel through the grates, etc., are kept, the lower the unit cost of power will be.

CO_2 Diagrams from Actual Practice

By A. Bement*

SYNOPSIS—A number of interesting cases in which the results of analysis are connected with the performance of the fire. From the results improved methods of firing were introduced and the system was used as a check on the firemen.

The difficulty experienced by the average man is inability to connect the results of analysis of flue gases with the performance of the fire. It is of no use to him to know that CO_2 is low or that air is in large excess unless he knows how to correct the condition, and it is only by establishing a very direct and close connection between the performance of the fire and the indications of the analysis that a proper understanding may be obtained. The Orsat apparatus is a comparatively simple and low-priced device. Its disadvantage is, for the purpose in question, that it is slow, and before the engineer can get the result the condition has changed; or that he is so closely engaged in getting the sample and analyzing it, that he does not observe furnace conditions, and for this reason the combustion performance is not "caught in the act."

My experience began with the indication of CO_2 employing an Econometer, a device which indicated immediately the per cent. of CO_2 in the gases. Familiarity with this instrument and with the CO_2 determination before making use of an Orsat gave me a knowledge of the process, which never would have been acquired with the Orsat apparatus. I soon learned to watch furnace conditions, making this the main thing, and the reading of CO_2 accessory to it. For example, the condition, which might have been the cleaning of a fire, was noted, the time written down and observations made at one- or two-minute intervals of the CO_2 produced. Afterward these data were used in the preparation of a diagram, using per cent. of CO_2 as the vertical and time as the horizontal scale. This gave a diagram in many respects similar to the indicator diagram from an engine, and one which could be intelligently read, provided it was accompanied by some simple explanation, as given in the examples following:

Fig. 1 shows in condition *A* that the fire needed cleaning; that it was dirty was known, as it had not been cleaned for a considerable period. Now, as there was a considerable quantity of incandescent coal on the grate, it could not follow that the air supply was not sufficient. The real reason was that the entrance for air through the fuel bed was obstructed, so that the coal while plenty of it was present, burned slowly; but the natural leakage of air into the furnace was just as large as though there had been a brisk fire. A few minutes later condition *B* shows the improvement brought about by cleaning the fire; that these two conditions were, as is described, is shown by the following analysis with the Orsat apparatus.

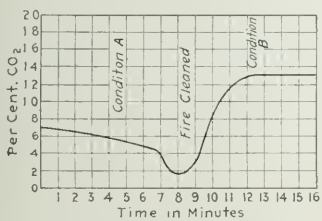


Fig. 1. Two Conditions of Combustion

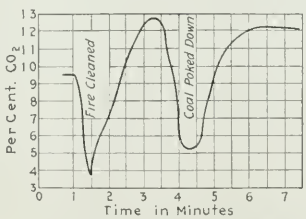


Fig. 2. Diagram from Acme Stoker

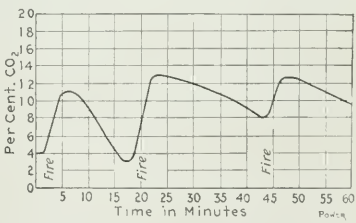


Fig. 3. Hand Firing

Conditions of Fire	*A* Dirty	*B* Clean
CO_2	6.5	13 0
CO	2 5	0 0
O_2	7.5	6 0

Thus it is apparent that one knowing from observation the conditions at *A* and *B* could immediately interpret the curve or diagram, and this method followed in all cases will make each example perfectly clear.

The remarks applying to Fig. 1 are also clearly illustrated in Fig. 2. This diagram is from a sloping grate stoker, with a dump grate at the bottom. Beginning with 9.5 per cent. CO_2 the fire was cleaned, with the result that the CO_2 immediately dropped to 3.7 per cent., recovering directly, however, when the dump grate was closed, and facilitated also by the fact that the firemen poked down out of the hopper on to the stoker grate a large quantity of fresh coal. The CO_2 rose to 12.7 per cent., after which it rapidly declined to 5.3 and soon recovered to a little over 12 per cent.

In this digaram there are two serious drops in CO_2. The first one was due to excessive air, but with fuel in

*Consulting engineer, 29 South La Salle St., Chicago

excess the second drop was due to an enormous volatilization from the coal, and instead of the carbon having a chance to enter into combination with oxygen it flowed away in great masses of smoke. This conclusion is verified by the fact that when this excessive fuel had burned down to normal condition the CO_2 rose above 12 per cent. Before the CO_2 determination was employed, it was thought that this excessive poking down of coal after cleaning was a desirable thing. After the facts were discovered, practice was so corrected that CO_2 rose immediately after cleaning the fire and proceeded at the maximum, the second drop being entirely absent.

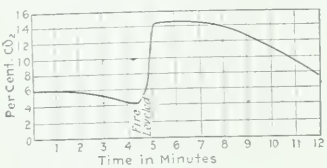


Fig. 4. Effect of Leveling Fire

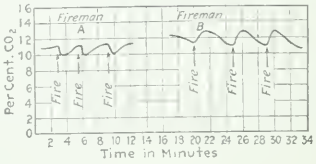


Fig. 5. Different Kinds of Hand Firing

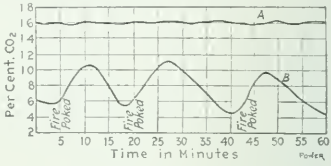


Fig. 6. Firing in Hawley Furnace

Fig. 3 shows results from hand firing typical of usual good practice. The rise of CO_2 accompanying the application of fresh coal is distinctly shown to a certain point, after which as the fire burns away it drops. In this case the second firing is seen to be better than the first one, because the CO_2 goes higher and continues longer. From this performance one may readily study the best method for hand firing.

Results of hand firing where the fuel bed was in a very open condition, allowing excessive air to flow through it, are shown in Fig. 4. At the interval when CO_2 began to increase, the fire was leveled with a rake and the open-

Fig. 6 shows two curves taken from a Hawley furnace. Curve *B* shows the performance which habitually prevailed when the men were especially careful. The rises in CO_2 followed poking the fire on the upper grate. The practice was to poke down a certain amount of coal from the upper grate and allow it to burn in a pile upon the lower one, with only an indifferent leveling of the lower fire. Thus it appears that as the fire was poked, CO_2 rose, and as the fire on the upper grate became compact again and the fire on the lower grate burned away, CO_2 fell, to rise again at the next poking which was at a considerable interval. As it was apparent that when the fire was poked and the bottom grate leveled CO_2 rose, it would appear that a continual poking and a continual leveling would remedy the condition.

Therefore, in the experiments, the fireman devoted his entire time to poking the fire of the upper grate and to keeping that on the lower grate level and clean. The result was that the boiler, which had 3500 sq.ft. of heating surface and 120 sq.ft. of grate surface, half of which was in the upper grate and the rest in the lower, produced 850 hp. The labor was beyond the continual endurance of one man, so the draft was reduced and the coal-burning capacity brought down to the ability of the

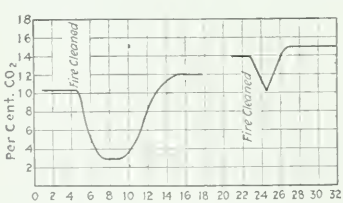


Fig. 7. Cleaning Fires in Hawley Furnace

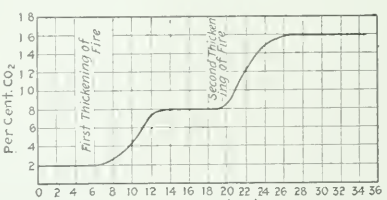


Fig. 8. Large Coal and Excess Air

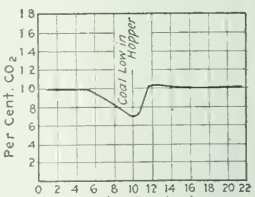


Fig. 9. Coal Low in Hopper of Chain Grate

ings closed. The air supply was more thoroughly employed and the CO_2 increased from 4.5 to 14.5, gradually dropping as the coal burned away.

Examples of the work of two different firemen are shown in Fig. 5. The furnace was large with six doors to be fired by hand. It was observed that whenever fireman A added coal the CO_2 dropped slightly because he dumped the coal with little or no care. Previous to the making of this diagram, it was not realized that there was anything wrong with his method. Fireman B, however, broke his coal properly and spread it carefully, with the result that a rise in CO_2 immediately followed each firing. As the furnace was large the firing was continuous, with slight intervals between shovels but with no decided intervals between firings.

man. At this point proper manipulation gave the efficient performance indicated by curve A, which is in marked contrast to previous practice shown by curve *B*.

Some typical examples of the results due to the time taken in cleaning fires in the Hawley furnace are shown in Fig. 7. The first diagram, showing a large drop, represents a condition with which no one found fault until a CO_2 diagram had been made. The second diagram shows what was readily attainable after a little experience.

Fig. 8 illustrates a serious trouble. The plant was equipped with Hawley furnaces and screenings had been used, the fuel bed being about 8 in. deep. In an emergency it was necessary to use lump coal. The men being familiar with an 8-in. fire followed that practice with

the lump coal. As only the edges of the lump came together, large spaces were left for the flow of air, and this air was in such excess that nearly all the heat went up the chimney and there was little or none available for making steam. An inspection of the fires did not reveal the difficulty, as the coal burned rapidly, the fire roared and the men were shoveling in lots of coal. No one thought to look at the Econometer, which was in operation, and the trouble man was sent for. Upon his arrival he looked at the instrument and saw only 2 per cent. of CO_2, which suggested excess air. A glimpse at the fire confirmed this. He ordered the fireman to "fill up the furnace, pile it full of coal." As he began to add the coal, CO_2 increased. After the fireman had put in coal enough to make the fuel bed about twice as thick, CO_2 went to 8 per cent. At this point the fireman seemed satisfied, but was told to again fill up the furnace. He shoveled it entirely full, and the result was an increase of CO_2 from the point marked "second thickening of fire" to 16 per cent. When this had been done, the fireman sat down for an hour and watched it burn, and with this and the other thick fires steam was made in abundance.

A drop in CO_2, caused by letting the fuel in the hopper of a chain-grate stoker get low, is shown in Fig. 9. Many firemen think that it does no harm to let the fuel get low in the hopper, provided it does not get below the gate. This diagram shows the result of the coal being only a little way below the top. The CO_2 dropped from

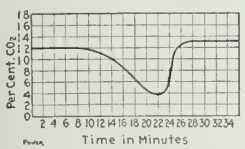


Fig. 10. Short Fire with a Chain Grate

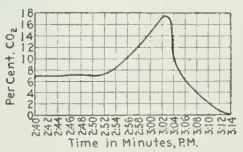


Fig. 11. An Emergency Curve

10 down to 7 per cent. and rose again as soon as the hopper was filled. Fig. 10 shows the result of allowing the fire to get short on a chain grate, and illustrates its recovery when the fireman "winds up" the grate.

Fig. 11 shows the advantage of sometimes being able to ascertain what has occurred in a past emergency. The plant from which this diagram was made was new and equipped with a CO_2 recorder. Trouble had been experienced from bridge-walls collapsing and a number of repairs had been made without knowing the cause. One day the CO_2 machine happened to be connected with one of the boilers during the time that a bridge-wall failed. When the expert arrived to look into the trouble he asked at what time the trouble occurred and was told that the boiler was taken off immediately after three o'clock. Consulting the record shown in the diagram, it was apparent that CO_2 had risen to a high point a few minutes after three o'clock.

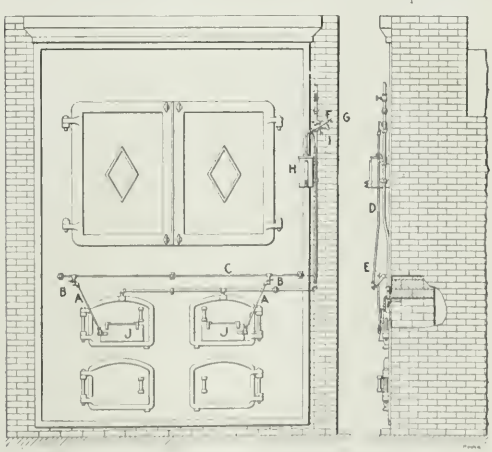
As a very high CO_2 indicates very high temperature, this evidence suggested that temperature may have played a part in the failure. An investigation showed that the interior of the bridge-wall contained common brick and was faced with firebrick. When an unusually good combination in size of coal entered the fire, CO_2 and temperature rose to a high point, with the result that the common brick melted and ran out of the wall, allowing the firebrick to collapse.

A plant equipped some years ago with Hawley furnaces made use of an Econometer to which a recording device had been attached. From each of the furnaces a pipe led to a header located at the instrument. Each one of these pipes had a stop-cock in it, so that any one of them could be cut in on the instrument. Experience showed that while the firemen were being watched they did much better work than when they were not. When the making of a record of CO_2 began, the men would look at the header to see what furnace was cut in and after they had discovered it, that one would receive special attention; the header was then so covered that they could not see which line was in use. Their next move to "beat the machine" was to take each furnace in series and do something abnormal with it while the instrument was carefully watched. In this way they again located the furnace from which the record was being made. The next step then was to cover up the front of the instrument so that they could not see it, with the result that a decided improvement in economy was secured.

Another example of the use of the instrument occurred in a plant which was equipped with a long row of boilers served by chain-grate stokers. The foreman whose office was in a little inclosed building carried a pipe along the whole battery, with branches to each furnace. This pipe ran behind the setting and in such a way that the firemen did not have access to it. When the foreman became suspicious of the workmanship of a fireman, he would cut on the furnace to the instrument, and when CO_2 fell he would walk back to the man, look into his furnace and call his attention to a short fire or some other condition. In this way he was able to immediately locate trouble.

Scharf Smoke Prevention System

The accompanying illustration shows the Scharf system of smoke prevention, based on the use of intermittent steam jets and automatic regulation of the air supplied over the fire. When one of the firedoors is opened the



Boiler Equipped with Scharf Smoke-Preventing System

rod A, connected to the arm B by a toggle joint, causes the shaft C to rotate part of a turn. This lifts the arm E and the vertical rod D and the lever F, hinged at G, is raised to a horizontal position. This action raises the plunger m in the oil-filled dashpot H and the lever valve I in the supply pipe of the steam jets is opened.

When the furnace door is closed, the dashpot piston is released, which then commences to sink to its original position. It also opens the half doors J, permitting an ample supply of air to enter the furnace over the fire. When the piston reaches its lowest position the half doors are closed once more and the steam jets are completely shut off.

The time required for this operation can be varied to suit firing conditions by adjusting the bypass valve which controls the flow of oil from the under to the upper side of the piston.

This system is manufactured by the Power Efficiency Corporation, Detroit, Mich.

Large Producer Gas Plant

The Canadian Car & Foundry Co., Fort William, Ont., has recently installed three 600-kw., 60-cycle, three-phase, 500-volt, alternating-current generators which will be driven by producer-gas engines. It is claimed that this will be the largest producer-gas plant in Canada. The engines are of the single-tandem, horizontal, double-acting, four-cycle type, with cylinders 28x36 in. and operating at 150 r.p.m.

The main gas plant consists of four double bituminous coal generator sets, and was originally intended for heating purposes, but as it is necessary to intermittently change from the water-gas operations to producer gas, it was decided to utilize the waste, or producer gas, for power purposes. This gas will contain more than 10 per cent. hydrogen by volume and is particularly suitable for use in gas engines.

The fuel gas, which will be used for furnace work, will have a heat value of 300 B.t.u. per cu.ft. and will contain about equal parts of hydrogen and carbon monoxide. The operation of the producers will be such that it will be practically impossible to mix the gases; that is, the regulation of the gas will be automatic, eliminating any liability of water gas being carried to the engines. In the use of double generating sets the gas is drawn off the top of one generator and down through the incandescent coal mass of the other, the tar being consumed and converted into gas, thereby increasing the efficiency of the plant. The resulting deposits of soot will be disposed of through a Thiesen washer.—*Electrical News.*

New Wheeler-Balcke Natural Draft Tower

In locations where condensing water is scarce, a properly designed cooling tower becomes equivalent to a natural water supply. If it operates with natural draft and no fan is used, the chief item of operating expense is the cost of lifting the water to the distributing system. The primary essentials for effective cooling are large capacity for dissipating heat to the atmosphere so that a large volume of water is cooled, and ability to dissipate this heat at a low temperature so that the water may be cooled as much as possible. To accomplish this, the water must present an extensive cooling surface to the air rising within the tower, and, secondly, there must be a brisk and vigorous air circulation.

In the new Wheeler-Balcke natural-draft chimney-type tower, illustrated herewith, the cooling is done on the "drop and film" principle. The cooling stacks are arranged in zigzag tiers which offer little resistance to the upward flow of the air. The cooling laths retard the downward flow of the water, spread it out into thin films and break it up into drops. Fig. 1 shows the construction of the tower. At the top is the vapor outlet, beneath

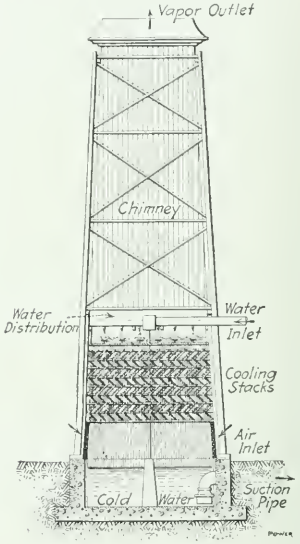


Fig. 1. Typical Layout of Cooling Tower

is the chimney, and next the water-distributing system which receives the water to be cooled from the water-inlet pipe and discharges it over the whole surface of the tower. Immediately below the distributing system are the cooling stacks and the air inlets, and at the lowest point is the cold-water well in which the water is collected and drawn off to the condenser.

The chimney and vapor outlet are of cypress boards supported by a framework of yellow pine, both woods being specially treated to prevent deterioration. The main trough into which the water is discharged from the inlet is of cypress planks 1½ in. thick. From this trough the water flows into lateral gutters, which in turn distribute it over the entire area of the tower by means of iron pipes arranged at equal intervals in the length of the gutters. The water falling from these pipes impinges upon galvanized-steel splash plates which break it up into a fine spray. In the form of spray the water then drops upon the triangular cooling laths below, which are arranged in zigzag tiers, as shown in the accompanying drawing. The zigzag arrangement insures the breaking up and turning over of the water without presenting high resistance to the rising column of air. The comparative space occupied by the cooling stacks and the location of the air inlet is apparent in the drawing.

In large towers the multicellular design, shown in Fig. 2, is used. Owing to the resistance of the falling shower of water, air will not penetrate to the center of the large tower, and the water in that region will not be cooled as efficiently as that falling in other parts nearer the shell. With the multicellular design, air is evenly distributed

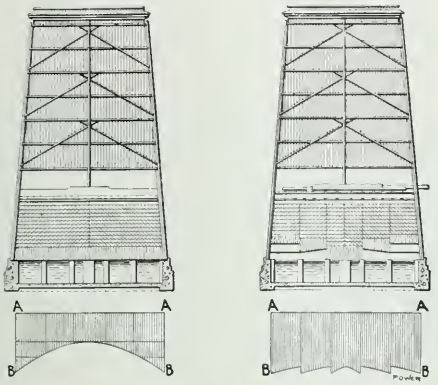


Fig. 2. Multicellular Tower with Temperature Diagrams below

to all parts of the tower, and the water in the center is cooled to practically as low a temperature as the water near the shell. The diagrams below the illustrations of the tower demonstrate this point. Here the line *AA* represents the temperature of the water entering the tower and *BB* represents the temperature of the water at various points in the cross-section of the tower as it falls from the cooling stack. In the multicellular design, it will be noticed that the temperature of the water as it is discharged is nearly uniform, while in the single tower the

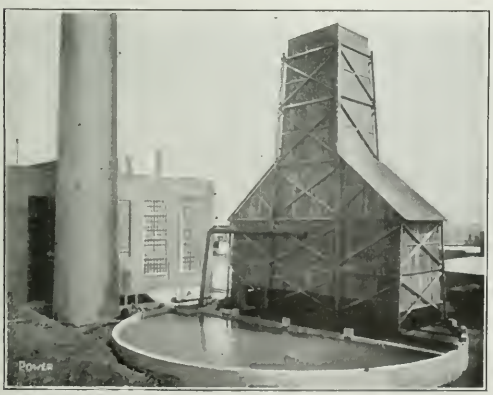


Fig. 3. Wheeler-Balcke Tower Installed at Plano Works of International Harvester Co.

temperature of the water at the center is considerably higher than at the sides.

Fig. 3 shows a tower of 72,000 gal. per hr. cooling capacity installed at the Plano Works of the International Harvester Co., West Pullman, Ill. As may be seen, the tower is erected over a concrete reservoir, which is large enough for a second tower of equal size. The reservoir is 75 ft. in diameter and has a capacity of 600,000 gal., forming a large, cold well and also a reserve supply of water for the fire pumps. The cooling tower operates in connection with two jet condensers. The tail pumps discharge directly to the distributors of the cooling tower through the pipe, which may be clearly seen in Fig. 3. The elevation of the distributors may be estimated from the height of this pipe. The base of the tower is somewhat above the elevation of the turbine-room floor and is at a considerably higher elevation than the condensers, which are in the basement beneath the turbine. Flooding of the condensers in case of failure of the vacuum is prevented by siphons in the suction lines.

RESULT OF TESTS OF COOLING TOWER AT INTERNATIONAL HARVESTER CO'S WEST PULLMAN PLANT

Test No.	Date 1912 Sept	Gal. per Min.	Water Temp. In	Water Temp. Out	Air Temp. In	Air Temp. Out	Air Humidity In	Air Humidity Out	Weather
2	11	1230	112	87	71	99	69	100	Strong wind, cloudy
3	11	1230	112	85	71	102	56	100	Strong wind, cloudy
4	11	1230	111	86	69	96	64	100	Strong wind, cloudy
5	12	1230	105	83	71	93	56	100	Light breeze, clear
6	12	1230	106	81	74	95	56	100	Light breeze, clear
7	12	1230	106	82	77	97	49	100	Brisk breeze, clear
8	12	1230	106	82	78	96	49	100	Brisk breeze, cloudy
9	13	1200	102	82	74	91	47	100	Light breeze, clear
10	13	1200	103	81	75	93	47	100	Light breeze, clear
11	16	2100	97	83	65	92	73	100	Light wind, clear
12	16	1700	101	83	68	95	62	100	Light wind, clear
13	16	1520	104	85	72	94	57	100	Light wind, cloudy
14	16	1520	104	85	70	95	68	100	Light wind, cloudy
15	17	1620	99	82	63	92	84	100	No breeze, cloudy
16	17	1280	106	82	63	96	84	100	No breeze, cloudy

The accompanying table is a summary of a number of tests conducted on this tower. It may be noticed that the air leaves the tower fully saturated. Tests 15 and 16 can be selected as showing the efficiency with which cooling is secured, even with high humidity of entering air. In each of the two cases cited the humidity was 84 per cent., the temperature of the air being 63. In test 15 the cooling was from 99 to 82 deg., and in test 16, from 106 to 82 deg.

About two weeks later, on a moderately warm but dry afternoon, the tower was supplying ejection water at about 72 deg. temperature and the vacuum on the turbine was slightly lower than 28 in. In a general way, this shows the possibilities of the tower during the summer. In the colder months of the year it will be evident that vacuums above 28 in. may be obtained.

A Small Office Building Plant

The Buffalo Natural Gas Fuel Co. is erecting a building at the northeast corner of Franklin and Church Sts. This building will generate its own electric current, and as it will be one of the smallest buildings on record to do this, the experiment will be worth watching.

The power plant will be a demonstration of the possibilities of a natural-gas engine, and will consist of three units of 150 hp. each. The electricity thus generated will run the refrigerating machinery, the house and fire pumps, the vacuum cleaner, the elevators and the auxiliaries. Supplementing this will be a storage battery which will help over the peak load and will be capable of running two hundred 25-watt lamps for eight hours.

This plant will occupy the sub-basement and will be so arranged that visitors may see the operation of the engines from the basement showrooms. The owning company will occupy the first and second floors, and basement, and the balance of the building will be rented.

ELECTRICAL DEPARTMENT

Remote Control through Street Mains

By Arthur H. Allen

An interesting method of remote control has been developed by W. Duddell, president of the Institution of Electrical Engineers, and Messrs. Handcock & Dykes, consulting electrical engineers, of London. It is intended to permit street lamps to be lighted and extinguished, two-rate meters to be controlled, etc., from the power house or substation, without any other means of transmission than the distributing mains themselves. It will readily be seen that such a system makes it possible to supply street and shop-front lamps from the ordinary mains, the customary method in England, and yet to switch them on and off at any desired time without using pilot leads or employing a number of lamplighters. Special systems of charging for electrical energy can also be adopted, such as that in which the rate of registration of a meter is accelerated during the time of heavy demand, and retarded during the daytime, dispensing with the use of two meters or a two-rate meter.

The principle of the invention is simply that of superposing upon the main supply current an auxiliary current of a different frequency, to which suitable relays respond at the points where the lamps, meters, etc., are situated. In the case of a direct-current supply the problem is easily solved: the relay is placed in shunt across the mains, with a condenser in series with it. No current passes through the relay circuit under normal conditions, but when an alternating current is injected into the direct-current supply, as, for instance, by cutting in a small alternating-current generator in series with the mains, the alternating current flows through the relay circuit and actuates the mechanism, which closes a switch or performs any other desired operation in a manner familiar to electricians.

Where the supply is alternating, the matter is not so simple. In this case the relay must be selective, responding only to a particular frequency, and this result is obtained by correctly proportioning the inductance and capacity of the relay circuit so as to produce resonance at the said frequency. In passing, it may be pointed out that selective relays are useful also on a direct-current supply, as they may be tuned to different frequencies, to effect different purposes. A large number of different frequencies may be employed, and the facility of tuning is such that a potential difference at the terminals of the relay may thus be obtained which is ten times that of the supply circuit, so that there is no risk of the relay being actuated at any time except the appointed moment. Where the supply is alternating, the inventors find it desirable to use frequencies comprised between the third and fifth harmonics of the supply frequency, and a superposed voltage about 5 per cent. of the supply voltage. There is no appreciable interference between the superposed current and the normal current, owing to the difference in frequency, the former being merely a ripple.

In practice it is found that the simple relay and condenser circuit, K and L, Fig. 1, while satisfactory on a direct-current system, does not afford sufficient margin for adjustment on alternating-current circuits. If the tuning is sharp, so as to prevent operation by the normal frequency of the circuit, a slight variation in the frequency of the superposed current will result in failure to operate, while if the tuning is not sharp, the relay may operate with the supply frequency. To overcome this difficulty, a second winding L_1 is applied to the relay, in circuit with a choke coil L_2. The current in the latter circuit is nearly 180 deg. out of phase with that in the normal relay winding, and practically neutralizes the effect of the normal supply current, leaving the resonance current master of the situation. A compensated relay of this kind operates with certainty at 5 volts, 200 cycles, on a supply circuit at 100 volts, 50 cycles, and even if the supply voltage is increased by 100 per cent. the relay is not affected. Moreover, the frequency of the superposed current can be varied 5 per cent. up or down without causing failure to operate. The power absorbed by the relay at 100 volts, 50 cycles, is only 0.7 watt, from the normal supply, and the same power, at 5 volts, 200 cycles, is sufficient to cause it to operate. To send the ripple over the mains, a small alternating-current generator can be cut into circuit, or it can be coupled to the primary of a transformer, the secondary of which is in circuit with the mains. The frequency of the generator can, of course, be varied according to the particular set of relays that it is desired to operate, and obviously the relays can be wound and the condensers chosen to suit any ordinary supply voltage and frequency. The coils L and L_1 on the relay can also be combined, as they are in Fig. 2.

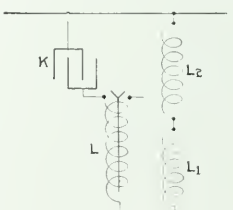


Fig. 1.

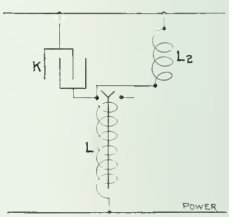


Fig. 2.

Relays and Choke Coils for Remote Control

In addition to the lighting and meter applications already mentioned, there are many other uses for this remote control system. Transformers in substations can be switched on and off whenever desired, the circuits of consumers who pay by contract for a fixed daily period of service can be cut in and out, time signals can be given to enable consumers to set their clocks right at specified hours, electric track signaling on alternating-current railways can be effected, etc.

Largest Direct Current Generators

The largest direct-current generators ever built have just been installed in the Canal Road plant of the Cleveland Electric Illuminating Co. There are two 3750-kw., 275-volt, shunt-wound machines, driven at 180 r.p.m., through 10 to 1 Westinghouse reduction gears by steam turbines. Fig. 1 shows the generator on the erecting floor in the Westinghouse shops, while Fig. 2 is a view of one of the units after being installed. The former view

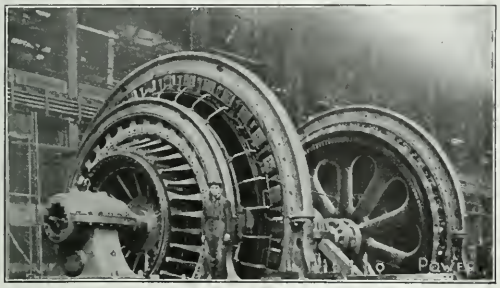


FIG. 1. GENERATORS ON ERECTING FLOOR

gives an idea of the size of these machines by comparison with a man of ordinary height standing beside them.

The large gear of the speed-reduction mechanism, Fig. 3, is 100 in. in diameter and has 259 teeth. The pinion has 26 teeth and a speed of approximately 54 miles an hour is attained at the pitch line. At full rated load of the generator the gear transmits over 5000 hp. and, on several occasions during overloads, has carried 6000 hp.

These two machines will supply light and power to the business section of Cleveland. The company's system was originally three-wire Edison but, as the business increased, alternating current was distributed to the outlying districts. The downtown business district, however, was never changed and is still fed from a three-wire system. The company also furnishes steam heat to this district.

When the new Lakeshore plant (see description in Mar. 18 issue) was designed, it was decided to let this supply

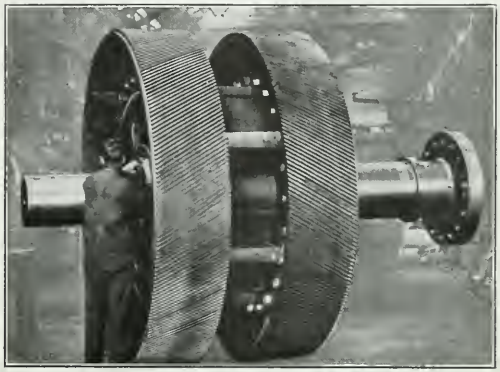


FIG. 3. LARGE GEAR

the alternating current and have the Canal Road plant a strictly direct-current station. A consideration which largely determined this was the fact that the Lakeshore plant is nearly four miles from the business center, while the Canal Road plant is only a few blocks away; hence, the ability of the latter to supply exhaust steam for heating.

It is the intention of the company to run these direct-current generators only during the months in which exhaust steam is required for heating, the Lakeshore station supplying the three-wire system through rotary converters during the other months.

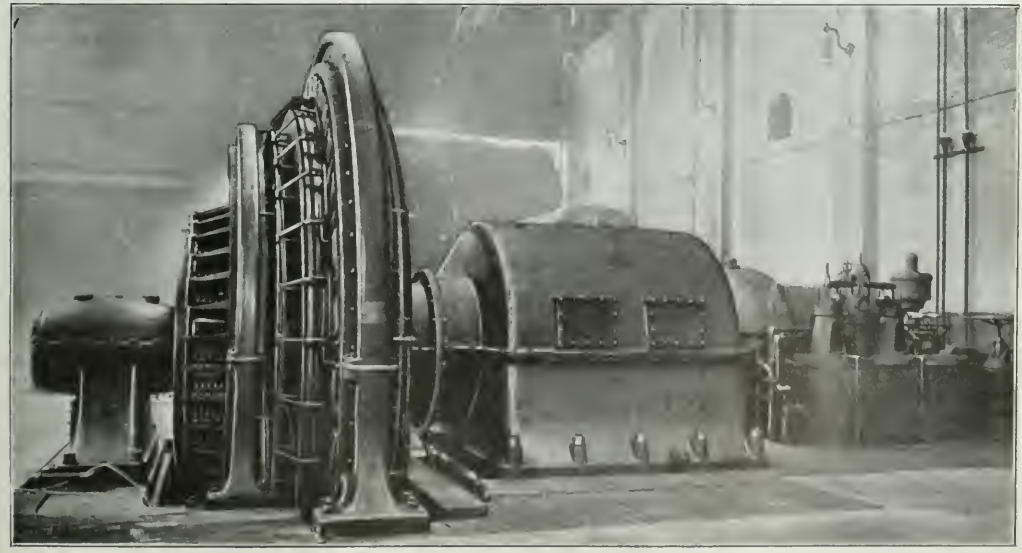


FIG. 2. UNIT FROM GENERATOR END

Rotary Converter without Shunt Field

Mr. Hill's question in the Feb. 20 issue of POWER, as to what would happen if a loaded rotary converter should lose its shunt field, is rather indefinite, as he fails to state the type of machine and the conditions under which it was operating, which would produce widely varying results.

In one instance, I was dusting the switchboard and the cloth caught on the field switch and opened it. Two 100-kw. machines were carrying the load and the station was running in parallel with a number of others on the same system, the nearest being about half a mile away. The two machines were connected in series on a three-wire system and were carrying about 25 per cent. load; the fields were very weak. When the field switch was opened, the machines dropped very little of the load and the voltage remained practically normal, as there was no indication of the trouble on the recording voltmeters.

The second case happened with a 500-kw., six-phase machine, running alone and carrying about 75 per cent. load. The station was practically isolated, being connected to the nearest station, over a mile away, by one small line. The connection between two of the field coils became loose and burned off, opening the field circuit. The machine then carried about 50 per cent. load with the induction regulator in full boost position, until we located the trouble. The power factor was below the range of the power-factor meter, which indicated as low as 50 per cent.

Another time one of the operators accidentally opened the field switch through his shirt sleeve getting caught on the switch. This was a 1000-kw., six-phase machine, running in parallel with four others of the same type and capacity. The opening of the field switch was accompanied by some fireworks at the commutator and the direct-current circuit-breakers opened from the reverse circuit relays. These operated to open the circuit-breakers when the reverse current became 50 per cent. of the normal full-load current.

In all these cases, the machines were single shunt-wound, with an induction regulator on the alternating-current side, and running on a three-wire, 230-volt Edison system.

The next time I saw this happen, was in a street-railway substation. This was a 1000-kw., six-phase, 600-volt, compound-wound machine, running in parallel with another of the same type and capacity. The operator, in trying to straighten a bent field connection, broke it off. Instantly, there was flashing and the circuit-breakers on both machines opened.

Another time, while starting from the alternating-current side, I forgot to close the shunt-field circuit after the machine was up to speed and after cutting in the machine picked up some load before I became aware of the fact. The machine was carrying about 10 per cent. load when I happened to notice the alternating-current ammeter showing about that much excess over full-load rating. The power-factor meter was out of order or I would have noticed the slip sooner. I reduced the load to zero again, the alternating-current ammeter then indicating about full-load current. Without making any further experiments, I closed the field switch and picked up the load.

From these two indications, it would seem that it takes about full-load current to run the machine and excite the fields and, from this point, the current increases at normal rate in proportion to the load. On this assumption, the power factor would vary from about 5 per cent. at no load to 50 per cent. at full load, provided it was possible to make the machine carry full load.

THOMAS G. THURSTON.

Chicago, Ill.

In the Feb. 25 issue, N. M. Hill asks what would happen if a rotary converter should lose its shunt field. I had an experience some time ago, which might be of interest to Mr. Hill. Being called upon to investigate operating troubles on a 200-kw., 60-cycle, self-starting rotary converter for railway service, I was surprised to find that the converter had been operating for a month, or since its installation, without a shunt field. During installation the field switch had been wired incorrectly, leaving the shunt-field circuit entirely open on either position of the switch.

The converter was carrying loads up to 25 per cent. above its normal rating without the shunt field, but it was noted that it heated up more on no load, or light loads, than on full load, also it was noted that the alternating current supplied to the machine was just about the same whether the machine was delivering zero or full load on the direct-current side.

Unfortunately, there was no power-factor meter on this converter, but undoubtedly the power factor was down almost to zero on no load and light loads, improving as the direct-current load increased.

The magnetic flux required in the magnetic circuit of a rotary converter is produced by either of two sources: by current in the field windings or by current in the armature winding. When the exact amount of flux required by the machine is not provided by the field excitation, it is automatically provided by leading or lagging currents in the armature winding. The magnetizing effect of leading currents is to oppose the initial field flux, while that of lagging currents tends to assist the initial field flux; hence in the case under consideration, the field flux at no or light loads was produced almost entirely by heavy wattless lagging currents flowing in the armature, and this current would cause the low power factor and heating noted at no or light loads.

Had this rotary converter been of larger capacity as compared with the size of the generating units supplying the alternating current, it is probable that it would have caused such a disturbance on the system that the trouble would have been detected at once, or had the converter been working properly at the start, and then suddenly lost its shunt field while running, the difference in operating conditions would have been noticed at once from the alternating-current ammeter readings, the heating of the armature, and the failure of the machine to respond to the moving of the shunt-field rheostat handle.

Again, had the converter been of the plain shunt-wound type, without the assistance received from the series field turns when the direct-current load came on, it is quite likely that the armature would have been damaged from heating, since the wattless currents would have remained high even when the direct-current load was high, and the combination of the two would work the copper in the armature far beyond its capacity.

Elmhurst, L. I. S. A. LEWIS.

GAS POWER DEPARTMENT

The Junkers Engine—VIII

By F. E. Junge

In the concluding article of this series it remains to discuss such points as reliability of operation, overhauling, friction, and dismantling, and general economic aspects of the Junkers engine.

Pistons and Lubrication

The long cylinder of the Junkers engine is open at both ends, and the extreme sections of the cylinders are well away from the combustion chambers. Thus these parts may be kept comparatively cool, and as with every revolution the pistons enter these well cooled sections, a constant exchange of heat is maintained between the pistons and the cylinder walls. Moreover, the lubrication is more favorable the lower the temperatures of the lubricated parts and, owing to the subdivision of the stroke between two pistons the distance traversed per stroke is diminished, thus increasing the lubrication efficiency.

Cracks in Combustion Space

Cracks occurring in cylinder walls are to be attributed largely to the stowage of heat in these parts, occasioned by nonuniform disposal of the material, and the restriction of the free expansion of the castings. In the Junkers engine the combustion chamber is surrounded by a smooth cylindrical shell of even thickness. The ends are formed by simple flat piston bottoms which admit of a uniform distribution of the material. An unrestricted free expansion of these castings is thus insured. In the Diesel engine of normal design circumstances are decidedly less favorable. The cylindrical shell inclosing the combustion space is provided with a heavy flange for receiving the cylinder cover. This flange, in combination with the clamping effect of the cover, does not permit of unrestricted radial expansion of the cylinder. The cover with its valve casings constitutes a complicated casting, of uneven distribution of material, in which the local stowage of heat is inevitable. A free expansion of this securely fixed casting is impossible. These parts are thus very apt to develop cracks.

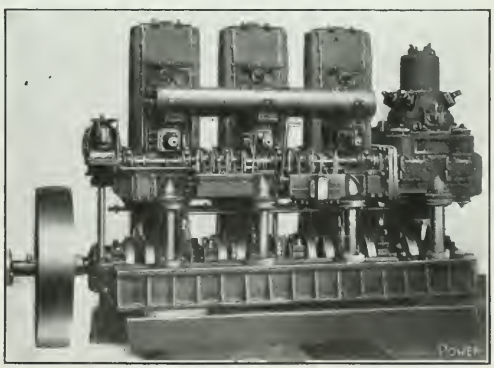
Valves

The Junkers engine possesses only a fuel injection valve and a compressed-air starting valve. These are of small dimensions and can be well controlled, as regards heating; undue heating of the valve springs cannot occur, since they are located far back from the cylinder. The valve-gear is simple and subject to little stress. After starting up with compressed air only the fuel injection valve-gear is kept permanently in operation.

On the other hand, in the normal Diesel engine, apart from the injection and starting valves, there are scavenging valves, fixed in the combustion chamber. With large engines these valves are heavy and as they have to be accelerated, retarded and again accelerated, within a fraction of a second, great stress is placed on the valve-gear. Moreover, the valves are all concentrated in the heated cylinder cover.

Overhauling, Erection and Dismantling

One of the chief demands with which a prime mover has to comply is provision for accessibility to those elements, which are most susceptible to wear, and to those parts which are most likely to get out of order and cause a breakdown. The overhauling and dismantling work connected with casual and periodic inspection must be done within the shortest time and by as few hands as possible. In an oil motor these inspections cover mainly the cylinders, pistons and valves, their seats and accessories. In this respect the Junkers engine offers great advantages, as those parts most susceptible to wear, the cylinders with their pistons and rings, are but slightly



150-HP. Junkers Engine

taxed, owing to the method of guiding, the relatively small piston speed and the good lubrication. Thus frequent inspection becomes unnecessary. If, however, such inspection should be required it may easily and speedily be accomplished by a few hands, since, for dismantling, only a few bolts have to be loosened. The fuel injection and starting valves are also easily inspected, the disconnecting of the valve-gear presenting little difficulty.

In the Diesel motors employing scavenging valves the seats of the latter and the valve disks require frequent attention, involving considerable labor, for one can get at these parts only by removing the heavy cylinder covers together with their complicated valve-gear.

Economic Considerations

The cost of production for a normal power unit depends mainly on the weight of the engine, and the wages paid for machining. Owing to the tandem arrangement of the Junkers engine, the interlocking of the forces in the driving mechanism, the high mean pressure, etc., the weight of the engine figures less than that of a normal two-stroke-cycle Diesel engine. Also the absence of in-

tricate castings and governing elements, and the simplicity of its parts make the machining costs less.

Life and Repairs

As already pointed out, the number of important parts given to wear are small, and delicate parts working permanently under high pressures and temperatures or other unfavorable conditions are absent; hence, the life of the engine may be considered long, whereas the running repairs and renewal costs may be considered small.

Efficiency and Fuel Consumption

Owing to the perfect utilization of the driving mechanism in the Junkers engine, the relief of the main bearings, the simple actuating of the pumps, the small throttling losses, etc., the mechanical efficiency is higher than that of the normal two-cycle Diesel engine, especially for large work; because in the case of the latter, large outputs are to be realized only by aggregating several single-cylinder units. The other favorable features in the Junkers engines pertaining to favorable heat transmission in the combustion chamber and excellent scavenging (pure and cold charge), insure complete combustion and a high thermal utilization of the supplied fuel energy. The fuel consumption is thus kept within reasonable limits.

The firms building Junkers engines on the European continent are: J. Frerichs & Co. A. G., Osterholz-Scharmbeck; "Weser" A. G., Bremen; Maschinenfabrik "Badenia," Weinheim; Maschinenbau Aktiengesellschaft vorm. Gebr. Klein, Dahlbruch; Ehrhardt & Sehmer, G.m. b. H., Saarbrücken; Allgemeine Elektrizitäts Gesellschaft, Berlin; Emanuel Nobel, St. Petersburg; Aktiengesellschaft "Sormowo," Sormovo, Russia. The accompanying illustration shows a 150-hp. single-acting Junkers engine built by J. Frerichs & Co., in Osterholz-Scharmbeck, Germany.

Carburetor Adjustments

By A. L. Brennan, Jr.

During the past few years gasoline engines have been improved very materially, but the quality of gasoline obtainable on the market has deteriorated and at present that supplied in some localities is very inferior. Looking at the subject broadly it may be said that the modern carburetors have maintained the efficiency of the internal-combustion motor, but have not improved it.

When carburetors were first called into use to convert gasoline into a highly combustible gas through its admixture with a given amount of air under normal conditions, no provision was made to supply artificial heat, the gasoline being highly volatile was readily taken up by the air. But the value of supplying artificial heat soon became apparent, either in the form of a hot-water jacket or by supplying hot air or both, and this was especially emphasized after the quality of gasoline started to decline. In one respect the modern carburetors are superior to earlier models, inasmuch as they are extremely flexible on one setting of the needle valve and they allow a wide range of speeds; of course, the auxiliary air valve has to be regulated in some cases.

It is impossible to lay down any fixed rules as to the proportions of gasoline and air for the best mixture, as there is no provision made for measuring these, but in practice it has been found that a mixture of high efficiency is composed approximately of one part gasoline to sixteen parts air. Since these proportions cannot be measured directly, the next best method is that of recognizing the symptoms of a faulty mixture and adjusting them accordingly.

Backfiring when attributable to a faulty mixture invariably indicates a weak mixture while sluggish operation usually points to a mixture that is over-rich.

Consider a new carburetor or one known to be out of adjustment and let it be desired to get an approximate adjustment that will allow the motor to be kept in operation until a further regulation of the air and gasoline can be had. Since the majority of carburetors are fitted with valves for controlling both the gasoline and air supply it will be quite necessary to adjust both of these and not merely the needle valve as is commonly supposed. Most carburetors operate with the needle valve open from three-quarters to one and one-half turns; therefore, if the valve is closed and then opened one turn it will generally suffice in getting the motor started at least. In regard to the air supply, a fair tension should be exerted by the air-check spring but should not be so great as to reduce the volume of gas the cylinder should get.

After making the foregoing adjustments the motor should be started. If on cranking, backfiring takes place, this would indicate too little gasoline or too much air. But in most cases this trouble will be overcome by allowing a little more gasoline at the needle valve. On the other hand, if the motor picked up its cycle but stopped in a sluggish manner, this would indicate too rich a mixture and steps must be taken to reduce the amount of gasoline fed by the needle valve. But it must be remembered that an approximate mixture must be had in order that the load can be placed on the motor, for the final regulation of the carburetor cannot be had until the motor is operating successfully under its average load.

When a final adjustment is had that allows high operating efficiency, any change that may from time to time be needed according to the speed of the engine can be taken care of by the auxiliary air valve. The needle valve should be left severely alone. This holds equally true when starting. The mixture being made slightly richer if necessary by recourse to the auxiliary air valve.

Now assuming that a good carburetor adjustment is had, which fact is clearly indicated by good operating efficiency, but that trouble unexpectedly develops which is traceable to the carburetor; this may be due to any one or more of the following:

Gasoline shut off or tank air locked;
Gasoline supply exhausted;
Water in carburetor;
Needle valve or pipe clogged;
Carburetor out of adjustment;
Low grade of gasoline;
Air intake obstructed;
Leaky manifold.

A few years ago it was not uncommon for floats to become heavy, due to fuel soaking and thus impair the efficiency of the carburetor, but this trouble is now seldom encountered as cork floats are covered with a suitable preservative and metal floats are used in many cases.

Any mechanical trouble that interferes with good compression also militates seriously against good carburetion and in order to realize good results from any carburetor the motor must be in good repair and adjustment.

REFRIGERATION DEPARTMENT

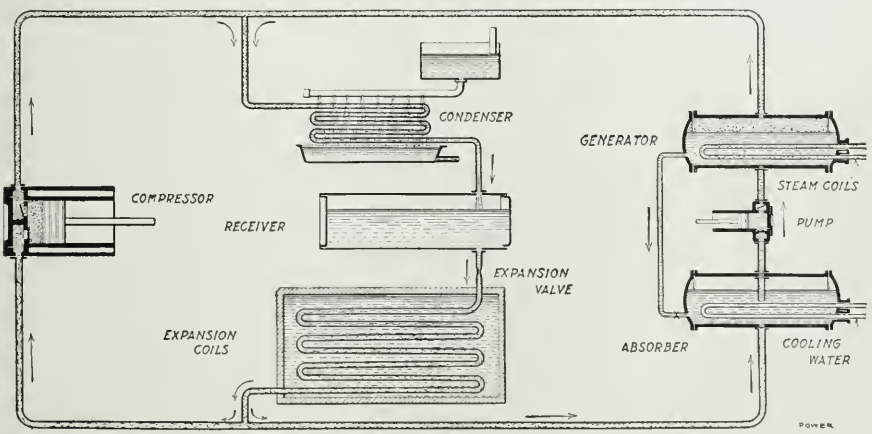
The Absorption System

Between the years 1850 and 1855, Ferdinand Carré, of France, invented the first practical ammonia absorption system. About the same time, 1855, Professor Twining, in America, and James Harrison, of Australia, independently perfected an ether compression machine, which had been invented in 1834 by an Englishman named Jacob Perkins. The absorption system took the lead, however, and for 30 years was almost universally used. Toward the end of this period, investigators began to realize how inefficient these early plants were, and turned their attention to developing the compression system. This type of plant was installed in large numbers, but the absorption system did not quite reach oblivion. The process was simple: the apparatus consisted of a number of inexpensive tanks, pipe coils and valves, and no motive power, with the exception of a small pump, was required. Improvements were made in the method of distilling and drying the gas; more of the waste heat was utilized; and the overall efficiency was considerably increased, so that the absorption system now has its place in refrigeration. Ordinarily it requires about the same amount of coal or its equivalent but a larger amount of cooling water than the compression system. Where exhaust steam is available from direct-acting steam pumps or a noncondensing steam plant, or both, the absorption system can be used to advantage. In combination with a heating load requiring about the same amount of steam, the conditions are ideal. In warm weather, the exhaust steam is utilized for refrigeration, and the balance of the year it fulfills the heating requirements.

The principle of operation is just the same as in the compression system, only the method of securing the results is different. For the compressor of the compression system, a generator, absorber and liquor pump are substituted. The balance of the system; that is, the condenser, expansion coils and expansion valve, may be similar. In practice, the brine system is generally used for an absorption plant, and either the brine system or direct expansion with the compression system.

To show the similarity between the two systems, the accompanying diagram has been prepared. The apparatus common to both, as shown in the center of the drawing, are the condenser, receiver, expansion valve and expansion coils. At the left is the compressor and at the right the apparatus which takes its place in the absorption system. Its action depends, primarily, on the high affinity of ammonia for water. At 60 deg. F., 1 cu.ft. of water will absorb about 700 cu.ft. of the vapor, and at 32 deg. and atmospheric pressure, the water will absorb 1000 times its volume.

In the issue of Mar. 11, on page 342, the cycle of events in the compression system was illustrated. From the expansion coils cold ammonia vapor was drawn into the compressor where its pressure and temperature were raised so that the boiling point would be above the temperature of the cooling water. This made it possible to condense the vapor into liquid, which was passed through the expansion valve and its pressure reduced from about 185 to 16 lb. gage. It then entered the expansion coils and remained in liquid form until it absorbed enough heat from the refrigerator to convert it into a vapor, this vapor passing on to the compressor as before.



Diagrammatic Comparison of Compression and Absorption Systems

In the absorption system, we will also start with the expansion coils. From there, the vapor passes on to the absorber, which is nothing but a cylindrical tank in which the ammonia is brought into contact with a supply of water. This water immediately absorbs as much ammonia vapor as it can hold, and, in this state, is commonly called strong liquor. The strong liquor is then pumped into the generator, or still as it is sometimes

called, for the liquid is here evaporated by means of steam coils supplied from a boiler or perhaps some source of exhaust steam. The ammonia in the rich liquor naturally evaporates more rapidly than the water, and the pressure of the vapor builds up in much the same way as steam pressure in a boiler. As with the compressor, this pressure must be high enough so that the vapor will be condensed by ordinary cooling water, this action taking place in the condenser. In liquid form, it then passes from the condenser to the expansion coils and, as before, abstracts heat from the refrigerator.

When most of the ammonia has been evaporated from the rich liquor in the generator, it is forced back to the absorber by the difference in pressure (usually 150 lb. or more) between the two apparatus. It is then known as weak liquor. From being in contact with the steam coils in the generator it is hot, and is cooled before it passes into the absorber, although the cold-water coils may be located directly in this apparatus. The weak liquor then collects in the bottom of the absorber and is ready to take up a fresh charge of ammonia vapor which, in its turn, is pumped to the generator.

This, in brief, explains the operation of the absorption system. In a plant under working conditions, there are a number of auxiliary apparatus which were not mentioned. For the sake of simplicity they were omitted, but will be included when the actual commercial plant is described.

Winter Work in Refrigerating Plant

By Fred Ophuls

This is the time of the year in which the operating engineer of a refrigerating or ice-making plant finds time to overhaul the machinery under his care and get it ready for next season's run. To do so thoroughly and get the best results from his labors, he consults the log books which he has kept during previous seasons and these show him the short-comings of various parts of the equipment.

In these log books he should keep complete records of the coal bought, ashes removed, water, oil and other supplies purchased, and above all, the results of the plant's operation, together with an account of the conditions under which they were obtained. There he should find most of the temperature and pressure readings and quantities, such as speeds of the various engines and pumps. This data, taken together, presents a complete story of the plant. It is of vital interest to him if he wants to improve the working of his plant and make it do better every season.

Besides this story he should find under the heading "Remarks" an account of the failures of parts of the plant at various times, of some repairs which had to be left for attention until it was possible to shut down for some time, and other points of importance in connection with the overhauling of the plant.

For simplicity the following remarks will be applied to a simple steam-driven can ice-making plant, although most of the remarks refer as well to the more complicated installations. Only the machinery and apparatus peculiar to ice-making and refrigerating plants will be considered in this article.

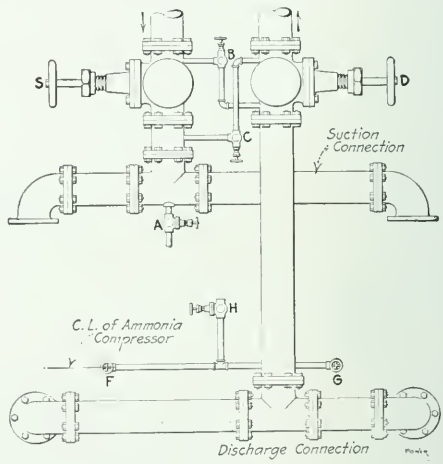
Falling Off in Capacity

In an ice-making system this can be due to a great many causes of which the following is a list of the principal ones:

1. Reduction in the pumping capacity of the ammonia compressor, caused by leakage of valves and piston, an unnecessarily low ammonia suction pressure, too much liquid ammonia entering the compressor with the vapors from the freezing tanks.

2. Disturbances in the operation of the liquifying and liquid ammonia-distributing systems, due to the scaling of the ammonia condensers and improper distribution of the cooling water over or through the condensers. In addition to this the available cooling surface of the condenser may be reduced by excessive quantities of noncondensible gases or too great or too little a charge of anhydrous ammonia. The temperature of the liquid ammonia at the point where it enters the expansion or pressure-reducing valve may be too high. It may short-circuit through a few of the brine-cooling coils or it may be impure.

3. Loss in efficiency and capacity of the ice-making system proper can arise from weak brine, the brine freezing on the brine-cooling coils, insufficient circulation of the brine, the propeller of the agitator being loose on the shaft, or having fallen from it, the level of the brine in the freezing tank being too low. It may also be due to filling the ice cans with distilled water not sufficiently cooled.



Compressor Piping

Let us look over the shoulder of the engineer and see whether or not we can learn anything of interest from the figures and notes before him. The reduction in the pumping capacity of the ammonia compressor is a serious matter and it is well to provide facilities for determining at any time whether or not the compressor and its immediate parts are in efficient operating condition. The engineer has made a slight addition in the ammonia connections around the ammonia compressor in order to attain this end. The leakage of compressor valves and the piston are difficult to determine by taking indicator diagrams, and in the accompanying sketch the ammonia connections are shown arranged in such a way that it is easy to find the causes of trouble.

It will be seen from the sketch that the ammonia suction and discharge connections are furnished with the

usual bypass or pump-out piping with shutoff valves *B* and *C*, and the ammonia compressor is also furnished with indicator or equalizing connections with stop valves *F* and *G*, terminating in the valve *H*, which opens to the atmosphere. In addition to this standard equipment a small-valved connection *A* is furnished in the suction connection to the machine.

Leakage Past Valves and Piston

To test for leakage, stop the machine and shut the stop valves *S* and *D*, as well as *B* and *C*. Then if the compressor has not been pumped out and the valve *A* is opened, the ammonia vapor contained in the short suction pipe between the stop valve *S* and the compressor escapes. Then open stop valves *F* and *G* to equalize the pressure on both sides of the piston and open valve *H* and let the ammonia vapor in the compressor cylinder escape. In case the discharge valves of the compressor are tight, the flow of ammonia from valve *H* will stop as soon as the ammonia compressor is empty. Then open stop valve *D* a turn or two and if there is no flow from valve *H*, the compressor-discharge valves are sure to be in good shape.

On the other hand, if either one of these valves leaks, ammonia vapor will flow from valve *H*, and the discharge valves must be removed, inspected and when necessary reground and repaired. In many compressor constructions the discharge valves are located in cages with separate valve seats. The joints between these parts and the compressor cylinder are either ground or made tight with gaskets. They are often the cause of the leaks as they are difficult to keep tight.

To test the suction valves, shut valves *F* and *G*, and allow high-pressure ammonia vapor to flow through the pump-out connection *C* into the compressor through the suction valves. When the cylinder is filled, shut valve *C* and open valve *A*. After the flow of vapor at *A* has stopped, find out whether or not high-pressure gas still exists on both sides of the compressor piston by opening first valve *F* and then valve *G*. If vapor escapes from the cylinder at both these points and none at *A*, the suction valves are tight. Otherwise the suction valves must be repaired.

Compressor piston leakage can be found, when all the valves are tight, by filling the compressor again with high-pressure vapor and allowing the vapor to escape from valve *F* until the flow stops. Then open valve *G* and if the piston is tight, high-pressure vapor will flow through the valve. In the event that all the vapor on both sides of the piston has escaped by way of valve *F*, the compressor piston rings and the compressor bore must be examined and repaired if necessary at the earliest opportunity.

In practice these tests do not take long, and where the size and location of the engine room permits, they should be made on each compressor at least once a month. Some engine rooms are so crowded and poorly located and ventilated that this is impossible and in these cases the indicator may be used with some success to determine leakage.

Condenser Troubles

Excessive ammonia condenser pressure always means a loss in plant efficiency. The higher the condenser pressure the greater the power to operate the refrigerating machine and the higher will generally be the temperature of the liquid ammonia leaving the condenser. It is often argued, in the case of a simple distilled water ice-making plant, that as long as the steam required to operate the machinery is just sufficient to produce the distilled water there is no economy in reducing the steam consumption of the refrigerating machine and of the auxiliaries. This is a fallacy, for about 2500 lb. of water must be evaporated in the boilers of such a plant to produce enough distilled water to manufacture a little over 2000 lb. of distilled water ice. At least 300 lb. of steam per ton of ice made is lost in the grease separator where it is removed as condensed steam with the oil used for lubrication.

To save 100 lb. of this waste would require a reduction of about 25 per cent. in the steam consumption of the engines and pumps of the plant. This saving often can be effected by reducing the condenser pressure and in various other ways, and it would mean a reduction of 4 per cent. in the coal pile, an amount which is well worth saving at the present prices of fuel.

Excessive condenser pressure can be produced by an inefficient condenser or by a good condenser under poor operating conditions. All condensers operating on the parallel flow or nearly parallel-flow principle are inefficient, whereas the counter-current-flow type will give best results. Experience with steam condensers for turbines has demonstrated that high speed of the steam and quick removal of the condensed steam from the condensing surface, are the prime factors in securing efficiency.

Too little attention is being paid to the temperature of the liquid ammonia as it leaves the ammonia condenser and as it enters the expansion valve. Every degree Fahrenheit that the liquid temperature is below the point of liquifaction in the condenser means a saving in power. It often is the case that a condenser, while producing a higher head pressure than one of somewhat different construction, will still be more economical, due to the low temperature of the liquid leaving it. This low temperature of the liquid must be preserved until it reaches the expansion valve or otherwise the benefits are lost. In case the liquid lines are of large dimensions and long and the liquid-storage tanks are of considerable capacity and located in the engine room there is often a considerable rise in the temperature of the liquid between the condenser and the expansion valve. This condition of affairs should be avoided by either relocating this part of the plant or else insulating it.

When making repairs and changes in the ammonia-condensing apparatus it is well to consider the above points and some simple calculations will enable the operating man to determine for his particular type of condenser, the most efficient condenser pressure, taking into consideration the steam required to pump the water over or through the condenser and that required for operating the refrigerating machine.

It is generally recognized that the closer the discharge and suction pressures approach, the smaller will be the horsepower per unit of refrigeration or ice making. That is to say, if the suction pressure of an ice-making system is maintained at 15 lb. per sq.in. gage and the condenser pressure could be maintained at practically the same pressure, no power would be required to circulate the refrigerating medium except that to overcome frictional resistances in the cycle. Such a condition of operation is, of course, impossible. But if the condenser pressure

can be maintained between 60 and 100 lb. the economical results of the plant will be far better than when the condenser pressure is maintained between 100 and 200 lb. gage.

The operating man with the data that he has accumulated after several years of operation can figure very readily which condenser pressures he should maintain at various times of the year for efficient operation and if the arrangement and construction of the liquid mains and their connections do not permit of operating the system with the low condenser pressures which he can obtain in the fall, winter and spring of the year, he must insist that they are changed. The change to be made is to place the liquid receivers just below the ammonia condensers and either remove the old liquid mains and connections and replace them by larger ones or else run additional lines to prevent excessive pressure drop between the liquid receiver and the expansion valves.

It is needless to call attention to the fact that scale on the condensing surface very much reduces its efficiency and when lime and other impurities are contained in the cooling water which are likely to form scale, the condensing surface should be frequently cleaned and if possible galvanized so that painting is not required. Painting condensing surfaces is not good practice as paint is a poor conductor of heat, and, moreover, does not stay on the pipe surface for any length of time on account of the excessive variations in the temperature of the pipe.

The reduction in the cooling and condensing surface on account of the presence of noncondensible gases can only be guarded against by frequent blowing off. These gases will form more rapidly as the difference between suction pressure and discharge pressure increases. While it has been often suggested to collect these gases in a separate receiver located over the condenser and connected with it, this method is not as effective as blowing off each condenser stand separately when practically all of the ammonia has been pumped back into the other stands of the condenser and the receiver. The importance of getting rid of these noncondensible gases is often overlooked by the operating man, but good practice demands that each condenser stand of a refrigerating or ice-making plant be blown down at least once every month. The loss of ammonia from this cause can be reduced to a small amount by careful manipulation and in that case the benefits of low condenser pressure will far offset the cost of the ammonia so lost.

Expansion Side of Plant

Weak brine will cause a disturbance in the circulation of the brine and also decrease the heat-conducting capacity of the freezing tank from the water in the cans to the coils submerged in the brine. It also disturbs the operation of the plant as the ice cans are liable to freeze fast to the coils.

Special attention should be paid to the circulation of the brine in the tank. It often happens on account of the inaccessibility of the brine agitator that the propellers become loose and even fall from the shafts, in which case the time of freezing the ice is increased. A great many can ice-freezing tanks lately constructed have been arranged with the necessary partitions and agitators so that the brine circulates from two to three times as rapidly as was the custom with the older construction. Care, however, must be taken not to increase the speed so much that the stability of the ice cans in the tank is endangered. In designing the brine-circulating system for a freezing tank it must be remembered that uniformity of circulation is of great importance. To operate a can ice-making plant efficiently it must be possible to draw the ice regularly. In many plants it is found that the ice freezes more rapidly in some of the cans of a row than in others, so that time is wasted in waiting for the slower cans to freeze up solid. If the circulation were uniform, the output of the freezing tank could often be increased from 5 to 15 per cent. The operating man who has had the opportunity to observe the freezing of the ice in the tanks under his care for a whole season's run will know exactly what parts of the tank freeze up more rapidly than others and by installing a wooden partition here or there in the tank or another agitator in the proper place, wonderful improvements in capacity can be obtained.

Often the level of the brine in the freezing tank is maintained too low. By watching his plant carefully the engineer can tell at what height the brine will give the best results. It must be remembered that as the ice freezes the volume of water and ice in the can increases. Some of the water still remaining unfrozen overflows the top of the ice cake and it is found that the height of the ice cake when it is frozen solid is nearly 9 per cent. higher than the body of water from which it is formed. It is also a fact that it is the water in the top of the can which it is most difficult to freeze up and by carrying the brine sufficiently high in the tank this part of the ice block can be made to freeze up solid nearly as fast as the bottom. If it is found that for such a height of brine the cans have a tendency to float, they should be secured in place either by wedges or else by using heavier cans made of say No. 14 iron with very wide bands around the tops, instead of No. 16 iron which is now the standard. The higher price of the heavier can is quickly offset by the reduction in the time of freezing.

The improper proportioning of the brine-cooling coils in the can ice-making tank often leads to unsatisfactory results, particularly when a change from the standard way of feeding the coils by means of separate expansion valves to the flooded or gravity feed system is used. A length of pipe coil which may be satisfactory when operating by means of separate expansion valves may be entirely out of proportion for good results when the flooded or gravity feed system is installed. This is the main reason why the flooded or gravity feed system has in so many cases proved unsatisfactory. If it is installed properly it will give at least as good results as feeding by separate expansion valves and in some cases even better results, due to the fact that its adjustment is more simple.

The foregoing remarks deal in a general way with some of the deductions that it was possible to make from the engineer's log. In a later issue it will be shown with the aid of some simple figures what the economies suggested really mean.

❖

Firing locomotives more economically, the aim of an educational campaign which the Lehigh Valley R.R. Co. has been conducting with its firemen, has resulted in a decrease of 5 per cent. in the amount of coal used per ton-mile in 1912 as compared with that for 1911. This is in spite of the facts that the road is running heavier trains than it was a year ago, and that many new firemen were hired in 1912.—"Engineering Record."

EDITORIALS

No Enabling Act

The engineers of New Jersey despairing, after thirty years' struggle with corporation-controlled legislatures, of ever getting a state law for the examination and licensing of engineers or the inspection of boilers or both, are now struggling for an act authorizing such municipalities as want such examination, license and inspection to effect it by local ordinances.

The argument of the advocates of this procedure is that it will be an opening wedge; that once a law of some kind is upon the statute book it will be easy to amend it and get what they want.

They are fooling themselves. Enabling acts have never paved the way to state laws, but have invariably been barriers to their enactment.

Future attempts to get a state law will be opposed by every department organized under the enabling act, with all the ardor, vigor, and systematic pertinacity of public officials fighting for their jobs.

An enabling act is not a breech in the defenses, it is an additional barricade.

If any city wants a local law, which it ought not as compared with a state law, the police and sanitary powers which it already possesses are sufficient for the establishment of a good workable department.

The uniform state law has got to come. When a few more states get laws like Massachusetts, Ohio, Montana and Minnesota, and the users of steam boilers and employers of engineers find that their object is to keep them from killing about four to five hundred folks, injuring nearly twice as many more, and destroying some half a million dollars worth of property a year, and not to make the proprietor change desks or residences with the engineer, they will look with more tolerance upon such laws and occasionally tell their legislators that they may pass an easy one and see how it will work.

⁂

Growth of Cast-iron Throttle Valve

Superheated steam having demonstrated its value in the power plant is here to stay, and will be more and more used as time goes on.

Troubles encountered in the early days of its use have been eliminated to a large extent. More suitable materials have been found for valve parts, and inordinately high temperatures of superheat have been abandoned. Today the average temperature of superheated steam used is between 100 and 125 deg. F. above that of saturated steam. At this temperature troubles in lubricating reciprocating engines have greatly diminished.

Interesting instances are found now and then where the action of superheated steam has caused trouble and anxiety to the engineer in charge. In one such a horizontal steam turbine operating under normal conditions suddenly developed a tendency to race. An investigation disclosed that the throttling valve, operated by the governor, and controlling the volume of steam admitted to the turbine was sticking, and as the governor could not operate it properly the turbine would gather speed when the valve stuck in the open position and decrease its speed when the valve finally gave way and moved toward the closed position.

This trouble with this particular turbine had occurred about every two weeks for some time previous and necessitated the removal of the valve for dressing down to fit in its chamber without binding. The trouble was caused by the cast-iron body of the valve growing under the influence of the superheated steam. One dressing would not make a permanent cure, but had to be repeated in about two weeks.

This particular valve is expected to attain its full growth in a few months, when the dismantling of the governor connections and valve will be a thing of the past. Just how much the cast-iron valve will have enlarged from the time it was first put in operation until it has reached its growth is a conjecture.

Dressing down the valve requires only about two hours, and does not affect the plant output in this case, as a spare unit can be started up, but, in a small plant, the sticking of the valve, if it became very pronounced, might tie up the entire service. A precaution against such an occurrence would be to attend to the valve at opportune times, even though sticking had not developed since the last dressing.

⁂

Feed-water Purifying Process

Human conviction is a funny thing. Many a man has been honestly convinced of a veritable impossibility, and by methods which, to him at least, must have been unquestionable and decisive.

The treatment of feed water, with respect to its scale-making qualities, is a favorite field for the exercise of this sort of hypnotism. It is possible to determine accurately how fast a boiler is scaling and positively whether a process of treatment is diminishing the rate at which scale is deposited—but nobody does it. The matter is usually one of judgment and judgment is flexible and often swayed by impalpable influences.

Some years ago there was placed upon the market a cylinder, in appearance like a small feed-water heater. All that was necessary to do was to let the feed water pass through it on its way to the boiler, and all the scale-making properties were gone. The promoters could show you any number of statements signed by reputable engineers to this effect. It was the acme of simplicity, and, if it really did what it was claimed to do and what these engineers thought it did, it would be in use in every steam plant today. So far as we know, it is not even upon the market.

A while ago, an engineer of more than ordinary intelligence told of a somewhat similar device which the inventor had installed in his plant. He was so much

in earnest about the thing, and talked so convincingly about it, that one of those who heard him called at his station when he happened in the city some months after to see it.

"The scale remover? Oh! yes," said the engineer, "we've thrown that out."

"What was the matter? Did it stop working?"

"No, it worked all right; took out most of the scale; but we opened it one day and found that there was nothing in it but a bunch of horseshoe magnets. I thought that if that was all it needed, we could magnetize the water easier than that, so I made a solenoid by wrapping some wire around the feed pipe, and I don't see but what it does just as much good as the tank."

And it probably did.

For a couple of years we have been reading of a German process of purifying water by letting it trickle over a tray of aluminum. If we remember correctly, sunlight is either requisite for or conducive to the process. Its results have been the subject for discussion by learned bodies, and most erudite theories have been advanced to account for them. We do not presume to challenge the efficacy nor orthodoxy of the process, but we cannot help wondering if it will be in evidence a half dozen years hence.

High Speed Bearings

J. G. K. Balfry, in a paper recently read before the Rugby Engineering Society, gives the following figures as representing the practice of the General Electric Co. in the design of turbine bearings:

Vel. of rubbing surfaces, ft. per sec.		Pressure allowed, lb per sq.in.		Product
20	×	167	=	2,340
34	×	190	=	6,460
40	×	208	=	8,320
60	×	229	=	13,740
73.5	×	235	=	17,270

Engineering, from which our knowledge of the paper is obtained, calls attention to the fact that the product of the velocity and the pressure amounts to over 17,000, with the highest velocity, whereas it used to be considered necessary to keep it within 2500. The use of forced lubrication is doubtless responsible for much of this possibility of using proportionately smaller bearings with higher speed.

Mr. Balfrey's paper brings out the fact that another time-honored practice is being abandoned by some firms when designing high-speed bearings. It has been the universal practice to cut oil grooves in the brasses. The theory of the high-speed bearing, however, as developed by Osborne Reynolds, robs these grooves of any obvious purpose, and, in fact, it might not unfairly be argued that they are actually detrimental. It is, therefore, of interest to note Mr. Balfrey's statement that some makers now consider grooving of this kind unnecessary, it being, they hold, sufficient to supply oil along the whole length of the bearing at about the horizontal center line.

Safety and Responsibility

A letter recently received on the above subject told of a boiler inspector who was about to test a safety valve by comparison with his gage when the engineer suggested that the inspector's gage first be tested with a dead-weight tester which the engineer happened to have. The gage was found to read 10 lb. light. Hence if the inspector had reset the valve it would have been set for 10 lb. too great a pressure.

The letter was not printed because it seemed to make too much of what is probably a very rare happening. That an inspector's test gage should be absolutely and unquestionably correct goes without saying. So should a physician's thermometer or any other measuring instrument upon the records of which much depends. These things are so patent there is no occasion to discuss them at any length.

The remissness of one inspector should not be held up as a reflection on the profession or any one but the single inspector who was negligent. In no field will every member be found faithful to his duties. In the case in question it may not have been carelessness, but unwitting confidence in an instrument that was presumed to be correct.

The moral of it all is that since so much is expected of a boiler inspector, he must walk more circumspectly than his less exalted brothers and see to it that no one can catch him with an inaccurate instrument or any other evidence of laxity in his work. If he has no pride in the matter a sense of his responsibility for the safety of a great many lives should make him unrelenting in his diligence and carefulness.

The two large horizontal return-tubular boilers which were tested to destruction by James E. Howard, formerly in charge of the Department of Tests at the Watertown Arsenal, and now connected with the U. S. Bureau of Standards, both failed at the cast-iron manhole frames (see POWER, Dec. 5, 1911). At other tests made shortly afterward by Alex M. Gow, at Ishpeming, Mich., on boilers owned by the Oliver Iron Mining Co., the boilers failed in the same way. We understand that the boilers, which exploded recently at the plant of the Howland Pulp & Paper Co. (see POWER, Feb. 4, 1913), gave out around the manholes, which also had cast-iron frames. This appears to be a vulnerable part of the shell boiler. The use of cast iron for this purpose has been abandoned, but many boilers with cast-iron frames are still in use and should be watched.

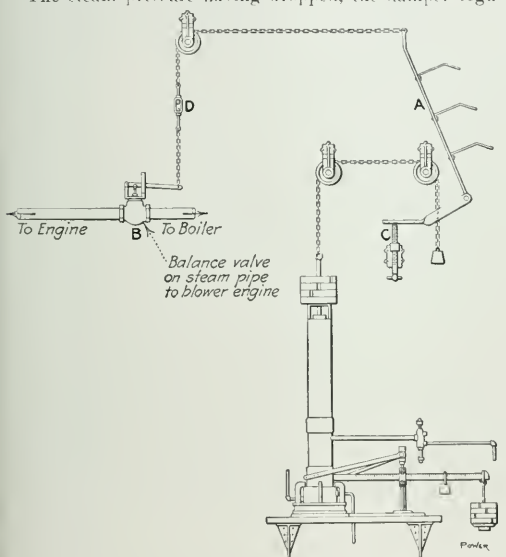
It is said that some four hundred horsepower will be required to overcome the bearing friction in the twenty thousand-kilowatt turbine which is being built by C. A. Parsons & Co. for the Commonwealth Station at Chicago. This is, however, only about one and a half per cent. of the capacity of the unit, and is equivalent to about as much heat as would be generated by burning some eighty pounds of coal per hour. The ability of the bearings to dissipate this is a striking illustration of the advance which has been made in bearings and their operation. The modern method of forced lubrication not only materially reduces the friction of the bearing, and thus the amount of heat which it generates, but the oil itself, which is circulated through a cooler, is made a vehicle for carrying off of heat at a much greater rate than that at which it could be dissipated by convection and radiation from the surfaces of the bearings themselves.

READERS WITH SOMETHING TO SAY

Forced Draft Outfit

A handy way to control forced draft is shown herewith. The steam pressure operates a damper regulator which controls the speed of the blower engine by operating a throttle valve in the engine steam-supply pipe. The arrangement works as follows:

The steam pressure having dropped, the damper regulator operates in the usual way and, as shown by the illustration, turns, by means of a wire cord and lever, the damper rod *A*, to which all of the dampers are connected. This operation also opens the balanced valve *B* in the steam line of the blower engine, and the engine speeds up.



Damper-control Apparatus

When the steam reaches the pressure for which the damper regulator is set, the operation is reversed, the damper nearly closing and the throttle nearly shutting off the steam to the blower engine so it does not come to a full stop. The amount of valve opening is adjusted by the turn buckle *D*. As the blower is always running slowly the damper must be open a little to let gases pass to the stack; this opening is adjusted by the adjusting bolt *C*.

Previous to applying means of regulating the draft a small hole was drilled through the seat in the balance valve to supply steam to the fan engine when running slowly, but this was not satisfactory. The new arrangement works very successfully and requires little or no attention. We are burning three parts screenings to one of soft coal.

East Boston, Mass. Clarence R. Davis.

Thawing Frozen Water Pipes

Starting a fire in a hot-water heater to thaw the contents of the circulation pipes is not a satisfactory method of procedure as will be attested by a chauffeur who tried it recently with disastrous result.

On entering the garage the extremely low temperature of the atmosphere suggested that the grooming of the automobile could best be conducted if the said temperature should be made more congenial. Following along the line of this instinctive suggestion the chauffeur conceived the idea that the hot-water heater could be placed in commission and the desired warmth easily and quickly obtained. An examination disclosed the fact that the contents of the pipes had congealed, but what regularly qualified chauffeur would be fazed by the simple proposition of converting the ice into water and subsequently heating the water? A fire was quickly kindled in the heater and as no visible effects were expected during the transmutation an adjournment to the comfort of the furnace-heated cellar of the adjacent house was in order. Lucky chauffeur! A few minutes later a "mysterious" explosion blew out the window of the garage, bulged the rear wall outwardly a distance of 6 in., seriously marred the glossy surface of the helpless automobile and, incidently, quickly and effectively removed the partitions of what was, in the days before automobiles had become indispensable, a harness-room wherein was located the heater.

When the excitement had somewhat subsided an investigation revealed that the heater was missing, but the ice which could be seen projecting from the ends of the broken pipes proved positively that the idea of firing up the heater to thaw the frozen contents of the pipes is not practical and therefore cannot be approved.

The chauffeur states that he was examined and licensed to "have charge and operate" automobiles and not hot-water heaters, although he is fast acquiring a fund of information on what "not to do" in manipulating the latter.

Charles F. Adams.

Lynn, Mass.

Deranged Cutoff Gear

One morning one of the two Corliss engines in a certain plant began taking steam at full stroke, but it was shut down before the flywheel reached the bursting point.

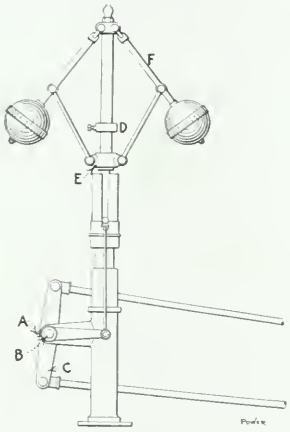
An examination of the valve-gear, etc., disclosed that the setscrew *A* in the governor arm *C* had worked loose, allowing the arm to turn on the shaft *B*. Then the steam-valve latch pushed the cam back out of the way, causing the engine to take steam full stroke.

The engineer set the arm *C* back to its proper place and marked the shaft and bell crank for future reference. The shaft and bell crank were then taken into the machine shop, a hole drilled and a pin fitted in where the

setscrew had been. This eliminated any danger from future trouble at this point.

One day at a later date, when the engineer was about to shut down the second engine, it began running at a terrific speed when the load was taken off. An examination showed that the key in the crank-end exhaust valve had worked loose. The key was driven home and after an examination the engine was started again. It came up to normal speed and then went higher as the throttle was opened.

It was noticed that when the engine was running at a little above normal speed the sleeve *E* on the governor came up against the collar *D*. That prevented the governor from going any higher, and no matter how fast the engine ran the cutoff remained the same. The engine was shut down, and the setscrew was loosened in the collar,



TROUBLESOME GOVERNOR

which was raised $\frac{3}{4}$ in. After the setscrew was set up the governor was blocked up to the collar and the engine started, but did not come quite up to speed. Then the block was taken from under the governor and the engine now governs with or without its load.

After the collar *D* had been raised, the safety stop was moved out of the way to be sure that the governor would come down to its proper place. On some makes of governor, if the collar *D* is too high, the governor arm *F* would be held up, and if the governor belt should break or run off, the safety would be of no use.

O. L. SHERMAN.

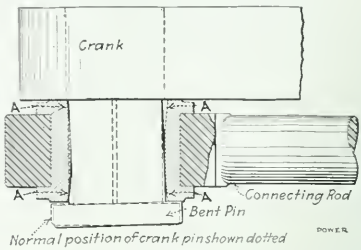
Duluth, Minn.

Running Engine with Badly Bent Crankpin

On a 10½ and 24 by 27-in. cross-compound vertical engine, the low-pressure crankpin became hot and tended to stick fast and both pin and brasses were badly scored; the crankpin was also bent. The connecting-rod end was of the marine type and no amount of oil would cool the pin, even when the bolts were slacked off two turns. With the bolts slacked off and the crankpin bent, the engine knocked very badly as it made 150 r.p.m.

While waiting for a new crankpin the trouble was overcome as follows:

The crankpin brasses were chamfered out as shown at *AAAA* in the illustration, until the rod swung evenly on each side of the crosshead-pin center in all crank positions. A little clearance was also given the brasses at the sides, so as not to allow them to bind while the engine was running. The crosshead-pin brasses were also made a little looser on the wristpin. With this arrangement



HOW THE BRASSES WERE CHAMFERED TO ALLOW BENT PIN TO TURN FREELY

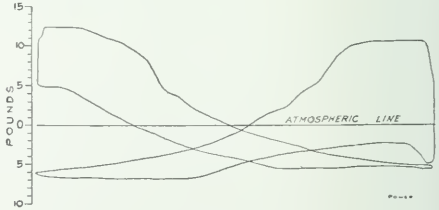
the crank brasses rolled on the crankpin as the crank rotated. The brasses were than made to fit as tight as possible without heating. This stopped the knocking almost completely and with plenty of oil supplied to the pin the engine ran without further trouble.

J. McA. HOWDEN.

Melbourne, Australia.

How Did It Happen?

These diagrams were taken from the low-pressure cylinder of a 12x22x18-in. single-eccentric Corliss cross-compound condensing engine connected to a vertical ammonia compressor. The boiler pressure was 100 lb., receiver pressure 14 lb., vacuum 24 in., speed 90 r.p.m., and the scale of the diagram 10 lb. per inch.



DIAGRAMS FROM LOW-PRESSURE CYLINDER

I found, after taking the diagrams, that the exhaust valves were line and line when the wristplate was in the center, so I thought everything was all right. But, upon taking out the valves, I found they were upside down. When I put them in again, the marks came exactly line and line, the same as when the valves were upside down.

I would like readers of POWER to suggest how this could have happened.

F. A. HUNTER.

Provincetown, Mass.

The National Tube Co. and some other manufacturers of pipe are to start the practice of rolling their names in the pipe. This decision is coincident with that of discontinuing the rolling of merchant (lighter than standard weight) pipe, and will save the purchaser from misrepresentation while any of the old merchant pipe remains on the market.

QUESTIONS BEFORE THE HOUSE

Buckling of Boiler Tubes

My attention has been called to the letter of C. R. Summers, in the issue of Jan. 14, undertaking to criticize my comments on the buckling of tubes in the Aug. 27 issue.

His intimation that my comments were theoretical rather than practical are not to the point. Nevertheless, I might add that they are based on actual working conditions in not only one but hundreds of various experiences. He seems to have overlooked entirely the point of my argument, which was the fact that the overheating and expansion of the tubes was, in most cases, the result of the scale deposit. He even makes me say that the scale in a water tube will hold it so tightly that it cannot expand.

My statement was to the effect that, when a tube expands it naturally expands along the lines of least resistance; that a water tube usually expands upward and a fire tube downward. Naturally, certain conditions can be created or conceived that would render the opposites of this statement true. There are exceptions to all rules. In fact, I illustrated the case of the arch tubes in locomotives where the scale is on the inside, but where the tubes carry a heavy weight, in which case the tube sags.

I ask Mr. Summers to examine the two lower rows of tubes in any water-tube boiler. Those are the tubes that are subjected to the greatest heat, yet when they buckle, that buckling is invariably upward.

If my theories are at fault, I am willing to acknowledge that I am in error, but Mr. Summers' argument is far from convincing.

C. S. Davis.

Buffalo, N. Y.

Mr. Booth's Condenser Problem*

The condenser problem presented by Booth in the Dec. 17 issue is very interesting. His analyses and statements are so clear that one wonders he was unable to arrive at a correct solution.

Mr. Booth notes that if the condenser got too hot "gravity got the upper hand and stopped the injector water supply." He understands that atmospheric pressure was the force that lifted the water at ordinary times and he knows atmospheric pressure was present on a hot day; then why did the water fail to rise? Let us begin here and work along to a solution and rest assured it will bear no resemblance to perpetual motion.

When that steam engine in the cotton mill completed a stroke and the exhaust valve opened, there was thrown away into the atmosphere a cylinderful of steam at, let us say, about 1 lb. pressure. For illustration it is unimportant whether it was exactly 1 or 3 or 6 lb. Likewise, the exact value of the latent heat in that steam is not important. Let us call it 1000 B.t.u. It is important to note that this steam is absolutely thrown away by the engine; so whatever loss or gain this may occasion elsewhere, cannot be reckoned as a detriment to the engine.

Every pound of steam exhausted by the engine contains about 1000 B.t.u., and this represents energy to the value of 778,000 ft.-lb., or sufficient energy to raise 45,000 lb. of water from the pond up the 17-ft. pipe into the condenser. But 40 lb. of water to each pound of steam is a liberal allowance for circulating purposes, though only a little of that energy can be used. Most of it must flow, as heat, into the pond and there be radiated to the atmosphere. While the weather is cool, this process goes on rather rapidly, but on a hot day these heat units persist in clinging to the water. In time the water gets so "elogged" up with them that it cannot absorb them fast enough in the condenser. The vacuum falls and trouble begins.

There is, then, plenty of heat energy in the steam to lift the water, but when the water cannot absorb this energy, the work stops. It begins to look as though Mr. Booth was correct when he surmised that the energy was supplied by the steam.

Let us make one more test. Cut off the steam from the condenser; water will now be lifted, not by a vacuum in the condenser, for that has disappeared, but by the direct action of the pump. We see now that we have not obtained our vacuum for nothing. To get it we have used heat units that cost money. And, from the fact that only when the water absorbs energy from the steam can we get the vacuum, which is the cause of the lift of the water, we must conclude that the energy is really furnished by the heat in the steam that the engine cannot use.

It cannot be shown that "the vacuum was or should be a trifle less as a result of the water climbing up against the action of gravity." Three things are needed to cause a flow of fluid: a region of low pressure (relative), a region of higher pressure and a connection between the two. The water in the pond was the region of higher pressure in this case, the injection pipe the link or connecting piece, and the condenser chamber the region of low pressure. Let us say we have there a vacuum of 24 in., or, an absolute pressure of 3 lb. Out on the pond we have a pressure of nearly 15 lb. per sq.in., or a difference of about 12 lb. per sq.in. And the pressure will be sufficient to sustain a column of water 24 ft. high, or, counting friction, bends, etc., it ought to lift water 20 ft., whereas the lift to the condenser is only 17 ft. From this we see that water would flow in too freely unless we decreased the flow of the injection water by partly closing the valve. Surely it would not help matters any to pump more water into the condenser, and if water will run in too freely from the pond, which is 17 ft. below the condenser, there could be no gain from letting water flow into the condenser from a tank on the roof.

*Previous discussion of this subject appeared in the Jan. 28 issue.

Only by converting the steam back into water can the engine get the energy represented in the latent heat of its exhaust steam. So the little work the steam does in forming the vacuum cannot lessen the efficiency of the engine, and since we must waste about a thousand times the energy required to raise the water, it is not going to help the situation if we use other energy to do this work.

WILLIAM E. DIXON.

Norwood, Mass.

The condenser problem proposed by W. H. Booth can be explained by the general theory of the siphon and the jet condenser. Let us analyze this case into its elements and see what we have by not allowing any steam to enter the condenser.

We can assume that the riser is full of water. This is true because we know that theoretically the atmospheric pressure will support a column of water 34 ft. high. When there is no steam admitted the pump raises the water 17 ft. by suction, and discharges it down the discharge pipe, the length of which is 17 ft. The latter part of the work is done by gravity, and the pump is really doing no work at all, except that of overcoming the friction of the water in the pipe, elbows, etc. We have practically a siphon; the down-going water raises the incoming water. The only work which the pump does is to overcome the friction of the water in the pipe. By changing the speed of the pump we change the quantity of water pumped.

Thus far we have had practically atmospheric pressure in the condenser. Suppose now that, in addition to simply running the water through the condenser, we admit exhaust steam, which comes in contact with the spray of the incoming water and thus condenses. By condensing, the steam produces a vacuum. The reason it produces a vacuum will be clear from the following figures: A pound of steam at atmospheric pressure occupies about 27 cu.ft. This same pound of steam suddenly cooled and changed into water (by a spray, for example), will occupy less than $^{2}/_{100}$ of a cu.ft. Thus we see that nearly the entire space suddenly contains no matter; that is, a vacuum is formed. The pressure would fall to zero if it were not that water always has some vapor present at any temperature, and that some noncondensable gases come in with the steam. To keep this vacuum continuous the pump must constantly remove the water, condensed steam and gases.

Now let us see the combination we have, siphon and condenser together. The water is sent up the risers, not by the pump, but by the difference between the pressure at the lower end of the riser and that within the condenser. The pressure of the water in the top of the riser equals atmospheric pressure minus that due to its 17 ft. of height. Since atmospheric pressure corresponds to about 34 ft. of water, the pressure in the riser corresponds to 34 ft. minus 17 ft., that is, 17 ft. of water. Therefore, for any water to flow, the vacuum in the pipe and condenser must be less than the pressure corresponding to 17 ft. of water. This vacuum is easily attainable and corresponds to about 15 in. of mercury. For the same reason that the pressure at the bottom of the riser is equal to 17 ft. of water, that at the top of the downtake pipe is equal to 17 ft. of water. Therefore, the only work which the pump must do is to force the water and gas from the vacuum pressure (less than 17 ft. of water) against the frictional resistance offered by the pipe. The rest of the work is done by gravity in the downtake pipe.

The energy to lift the water comes from the difference in pressure that exists between the vacuum and the top of the riser. The vacuum is not at all affected by the manner in which the water gets in, whether it falls in by gravity, is pumped in, or is sucked in. The vacuum depends on the amount which does get in and on its temperature. There must be enough cold water to condense all the steam entering the condenser. The quantity of water which will flow through a pipe depends on the difference of pressure causing the flow and on the diameter of the pipe. In the case we are discussing there must necessarily be a difference of pressure between the top of the riser and the vacuum of less than 17 ft. of water. Therefore, to get a large quantity of water we would need a large pipe.

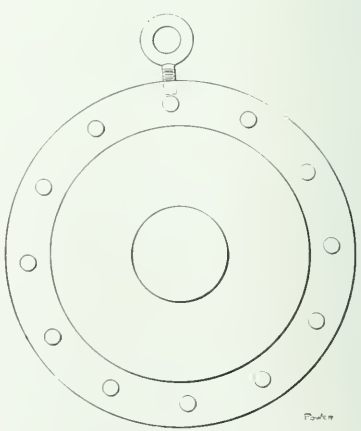
In the installation in question, the reason that "sometimes in summer gravity got the upper hand" is that the pipe was not large enough to supply sufficient condensing water, more water being needed in summer than in winter, because it is warmer and has less heat-absorbing capacity up to the temperature of the steam.

F. GITHENS.

New York City.

Removing Large Cylinder Heads

Having read of James McClure's sling for removing cylinder heads, I beg leave to submit the following sketch, illustrating a means for doing this that I have used very successfully on some large units of which I have had charge:



EYE-BOLT TO FACILITATE REMOVAL OF CYLINDER HEAD

The illustration is self-explanatory. An eye-bolt of the same diameter as the cylinder-head bolts is usually of sufficient strength to hold the head. A hook or rope may be passed through the eye-bolt when lifting off the head.

By lifting off a head in this manner the threads on the stud-bolts are not likely to become damaged, the tackle taking the weight of the head.

R. H. SCHAFER.

Trenton, N. J.

INQUIRIES OF GENERAL INTEREST

Rod Packing Thickness—Why are the stuffing boxes larger on larger engines, requiring larger packing, e.g., if ½-in. packing will hold on a rod 1½ in. in diameter why will it not hold on a rod 4 in. in diameter?

E. T. K.

The larger the diameter of a rod the greater is the circumferential length of the area to be kept packed, consequently the greater is the total elasticity required of the packing to keep it tight. The greater amount of elasticity is obtained by employing a thicker packing.

Pump Steam Consumption—Why do ordinary direct-acting steam pumps take more steam per horsepower per hour than steam engines?

L. S. W.

The larger consumption of steam pumps per horsepower-hour is not to be attributed to their not being well made, but rather to their having to take steam the full stroke, and the steam end is under other disadvantages of operation, as irregular and slower piston speed and greater waste of steam from necessary clearance spaces.

Repairing Bagged Boiler—How big a bag in a boiler would it be safe to drive back into place instead of cutting out the bag and putting in a hard patch?

A. L.

The size bag it would be safe to drive back would depend on the size of the boiler and the pressure carried. For boilers, 60 in. in diameter and upward, probably no bag larger than 10 in. in diameter nor bagging more than $\frac{1}{5}$ of its diameter should be forced back. If there is any doubt at all, it is better to cut out the bag and insert a patch with well-rounded corners.

Avoiding Static Electric Shocks—How can the shocks, due to static electricity, from belts, shafting and hangers be avoided? Does the static electricity affect motors or generators?

J. H. G.

Charges of static electricity can be dissipated by grounding some metallic part of each section affected with a gas or water pipe. A ground from a hanger will carry away the charge of static electricity from all parts in metallic contact with it. Any other section more or less insulated from the first will require a separate ground. The static charge has no effect on electrical machinery.

Meter Correction—What correction should be made to the reading of a meter calibrated to read in pounds of water at 212 deg. F., when the water is eight degrees hotter than boiling?

L. F. B.

A cubic foot of water at 212 deg F. weighs 59.833 lb. and at 220 deg. F., 59.63 lb., according to Landolt and Bornstein's Tables (1905). Hence, the reading of a volumetric meter, calibrated for 212 deg. F., should be multiplied by

$$\frac{59.63}{59.833} = 0.9966$$

to reduce it to the true weight of water at 220 deg. F.

Horsepower Constant—What is meant by the horsepower constant of an engine and how is it obtained?

I. A. R.

The horsepower constant is the number of horsepower per pound of mean effective pressure developed by an engine when running at its normal speed. It will be different for different speeds. Knowing the constant, one need only multiply the mean effective pressure (obtained from an indicator diagram) by this constant to know what indicated horsepower the engine is developing. Evidently, by the definition, the horsepower constant is all of the "PLAN" formula except the P, or

$$\frac{LAN}{33{,}000} = \text{constant}$$

which indicates, therefore, that to find the constant one should multiply the length of stroke in feet by the cross-sectional area of the cylinder in square inches, and by the number of strokes per minute (twice the number of revolutions) and divide by 33,000.

Height of Liquid in Horizontal Cylindrical Tank—To what height will 3000 gal. of water fill a horizontal cylindrical tank, 6 ft. in diameter and 25 ft. long?

K. T. E.

Presuming that the tank has one inward and one outward bumped head, its volume will be the same as if both ends were flat, and will equal

$$\frac{6 \times 6 \times 0.7854 \times 25 \times 1728}{231} = 5287.68 \text{ gal.}$$

The tank when containing 3000 gal. will therefore be ,

$$\frac{3000}{5287.68} = 0.567$$

part full

The area of a circle 1 ft. in diameter is 0.7854 sq.ft. and a horizontal tank 1 ft. in diameter, filled in the same proportion as the 6-ft. diameter tank when containing 3000 gal., would have 0.567 of the head submerged or

$$0.7854 \times 0.567 = 0.4453 \text{ sq.ft.}$$

This would leave.

$$0.7854 - 0.4453 = 0.34 \text{ sq.ft. unsubmerged.}$$

From a table of the areas of segments of a circle of diameter equal to 1, it is found that a segment of 0.34 area would have a height of 0.448, hence the submerged depth would be

$$1 - 0.448 = 0.552.$$

For a tank 6 ft. in diameter the depth would be

$$0.552 \times 6 = 3.312 \text{ ft.}$$

or about 3 ft. $3\frac{3}{4}$ in.

Computed Factor of Evaporation—The usual tables for factors of evaporation do not go above 212 deg. F. How can the factor be obtained when the feed water temperature is 220 deg. F.?

B. F. L.

The factor of evaporation for conditions beyond the range of the tables may be computed from the formula

$$F = \frac{H - h}{970.4}$$

where

H = Total heat above 32 deg. F. of 1 lb. of steam at boiler pressure

h = Total heat above 32 deg. F. of 1 lb. of feed water.

970.4 = Heat of evaporation, or latent heat of steam at 212 deg. F. (From Marks & Davis steam tables).

Suppose the boiler pressure to be 100 lb. gage, then the absolute pressure would be 114.7 or, practically, 115 lb. per sq.in. From the Marks & Davis tables, the value of H for 115 lb. abs. is 1188.8 B.t.u. and for h for 220 deg. F. 188.1 B.t.u. Substituting in the equation.

$$F = \frac{1188.8 - 188.1}{970.4} = \frac{1000.7}{970.4} = 1.0312$$

This shows that one factor cannot be obtained from another as given in a table by any percentage correction, but only as a difference. If tables of factors of evaporation are available for feed water at 200 deg. F., and for the existing boiler pressure, the actual factor can be computed as follows:

As the heat above 32 deg. F. in 1 lb. of feed water at 200 deg. F. is 167.94 B.t.u. and at 220 deg. F. 188.1 B.t.u. the correction is

$$\frac{188.1 - 167.94}{970.4} = \frac{20.16}{970.4} = 0.0208$$

i.e., to obtain the true factor of evaporation, when the temperature of the feed water is 220 deg. F., subtract 0.0208 from the factor for feed water at 200 deg. F

ENGINEERS' STUDY COURSE

Mensuration—Part VII

Spherical Segment

In the last lesson we learned that the volume of a sphere is equal to its surface multiplied by one-third of its radius, because the sphere can be considered to consist of a great number of pyramids of equal altitude with their apexes all meeting at the center. If we take away enough of these pyramids we might have a *spherical sector* as in Fig. 1 and the volume of this sector would be equal to the sum of the volumes of the pyramids remaining, so that the law still holds and the volume of the sector will equal the product of the surface of the part of the sphere left (in this case a zone) by one-third of the radius. Then, given any spherical sector of known radius, we have but to find the area of the zone to be in position to determine the sector's volume.

We also learned in the last lesson that the area of a zone is

$$A = 2 \pi R h$$

where

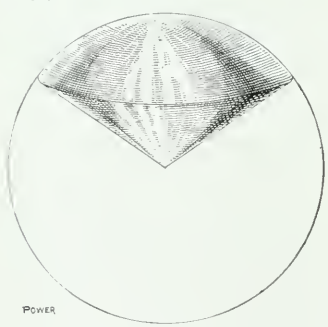


Fig. 1.

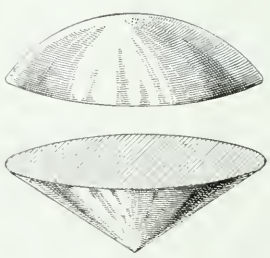


Fig. 2.

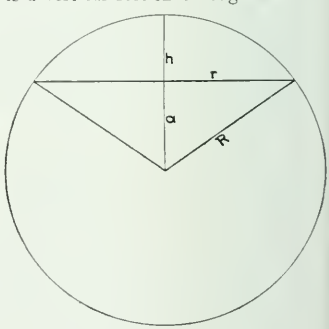


Fig. 3.

R = Radius of the sphere;
h = Height or altitude of the zone.

Now we can construct one formula for the volume of a spherical segment for we have seen that it will be

$$V = A \times \frac{R}{3}$$

Substituting the value of A and we have

$$V = 2 \pi R h \times \frac{R}{3} = \frac{2}{3} \pi R^2 h$$

From the forms that we have become familiar with we recognize in the spherical sector the combination of two—a spherical segment of one base and a cone—and we might separate them as in Fig. 2. Now we see at once the way to find the volume of a spherical segment of one base for we have only to subtract the volume of the cone from that of the spherical sector, both objects the volumes of which we now know how to determine.

Calling the radius of the base of the segment r, the volume of the cone is

$$V_1 = \frac{1}{3} a \times \pi r^2$$

where a is the altitude of the cone and equals the radius of the sphere minus the height of the segment or

$$a = R - h$$

Substituting in the last equation

$$V_1 = \frac{1}{3} (R - h) \times \pi r^2$$

Now, subtracting this volume from that of the spherical sector and the volume of the spherical segment of one base becomes

$$V_2 = \frac{2}{3} \pi R^2 h - [\frac{1}{3} (R - h) \times \pi r^2]$$

which reduces to

$$V_2 = \frac{\pi}{3} (2 R^2 h - r^2 R + r^2 h)$$

This formula is a bit awkward to use and involves both the radius of the sphere and the radius of the base of the segment, whereas generally only the radius of the base is known when it is desired to find the volume of a spherical segment. What we need then is to know the radius of the sphere in terms of the radius of the base.

In Fig. 3, which is a vertical section through the center of the sector, we find a right triangle formed by r, a and R and, as we learned some time ago,

$$R^2 = r^2 + a^2$$

To avoid bringing in a we will take its equivalent, $R - h$, and substitute it, then

$$R^2 = r^2 + (R - h)^2$$

which reduces to

$$R = \frac{r^2 + h^2}{2 h}$$

Now substituting this in our formula for the volume of the segment and

$$V_2 = \frac{\pi}{3} \left[2 \left(\frac{r^2 + h^2}{2 h} \right)^2 h - r^2 \left(\frac{r^2 + h^2}{2 h} \right) + r^2 h \right]$$

which is even more formidable, but this happily reduces (though we will not here go through the tedious algebraic process) to

$$V_2 = \frac{\pi}{6} h (3 r^2 + h^2) = 0.5236 h (3 r^2 + h^2)$$

which is a handy formula and may be stated as follows:

Rule: *To find the volume of a single-base spherical segment, add three times the square of the radius of the base to the square of the height and multiply the sum by the height and by 0.5236.*

In the rarer cases where the radius of the sphere is known but the radius of the base of the spherical segment is not known, we will need a formula which also may be

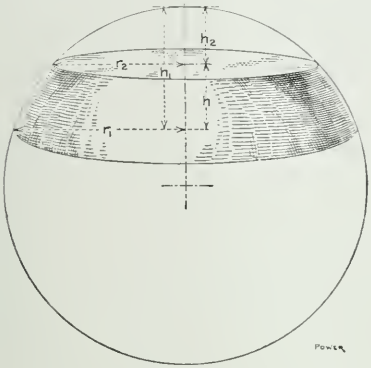


FIG. 4.

derived from the first one by substituting the value of r^2 in terms of R and h.

Going back again to the relation of the squares of the sides of a right triangle

$$R^2 = r^2 + (R - h)^2$$

this may also be solved for r^2, when it gives

$$r^2 = 2\,R\,h - h^2$$

Substituting this in the first equation for the segment volume and we have

$$V_2 = \frac{\pi}{3}\,[2\,R^2\,h - (2\,R\,h - h^2)\,R + (2\,R\,h - h^2)\,h]$$

which reduces to

$$V_2 = \pi\,h^2\left(R - \frac{h}{3}\right) = 3.1416\,h^2\left(R - \frac{h}{3}\right)$$

which, interpreted as a rule, states:

Rule: *To find the volume of a spherical segment, subtract one-third of the height of the segment from the radius of the sphere and multiply the difference by the square of the height and 3.1416.*

The last formula will be useful in the next step—to find the

VOLUME OF A SPHERICAL SEGMENT HAVING TWO BASES

Obviously the volume of a segment of two bases is the same thing as the difference between the volumes of two single-base segments, as indicated in Fig. 4, the larger one containing the smaller. Then the formula would be

$$V = \pi\,h_1^2\left(R - \frac{h_1}{3}\right) - \pi\,h_2^2\left(R - \frac{h_2}{3}\right)$$

where

h_1 = Height of the larger single-base segment;
h_2 = Height of the smaller single-base segment;

which reduces to

$$V = 1.5708\,h\left(r_1^2 + r_2^2 + \frac{h^2}{3}\right)$$

where

h = Height of the double-base segment;
r_1 = Radius of lower base;
r_2 = Radius of upper base.

Expressed as a rule this states:

Rule: *To find the volume of a double-base spherical segment, add the square of the radius of the lower base, the square of the radius of the upper base and one-third of the square of the height and multiply this sum by the height and 1.5708.*

Just to prove our formula let us take a segment with its lower base equal to a great circle and its upper base equal to zero. We know that such a segment would be half of a sphere or a hemisphere and its volume should prove to be half that of the whole sphere. Under these conditions

r_1 will equal R
r_2 will equal 0
h will equal R

Then substituting in the formula

$$V = 1.5708\,R\left(R^2 + 0 + \frac{R^2}{3}\right) = 1.5708\left(R^3 + \frac{R^3}{3}\right)$$

$$= 1.5708 \times \frac{4\,R^3}{3}$$

and since $1.5708 = \frac{\pi}{2}$

$$V = \frac{\pi}{2} \times \frac{4\,R^3}{3} = \frac{\pi}{6} \times 4\,R^3 = \frac{2}{3}\,\pi\,R^3$$

which, true enough, is one-half of $\frac{4}{3}\,\pi\,R^3$, the volume of a sphere.

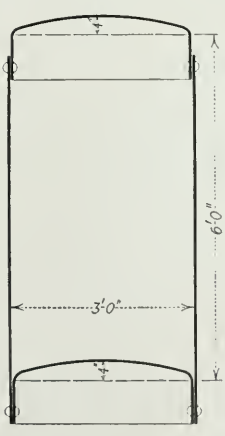


FIG. 5.

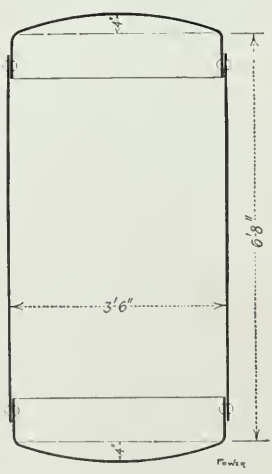


FIG. 6.

Example: What will be the volume of a two-base spherical segment, the height of which is 2 ft., the diameter of the lower base 8 ft. and that of the upper base 7 ft.?

Applying the formula, we get

$$V = 1.5708 \times 2 \times (4^2 + 3.5^2 + \frac{2^2}{3}) =$$

92.939 *cu.ft.* Ans.

Calculating Capacity of Bumped and Dished Head Tanks

The heads of bumped- and dished-head cylindrical tanks, such as those shown in Figs. 5 and 6, are usually in the form of single-base spherical segments.

We see that it is easy to find the volume of a tank with one bumped and one dished head, when the volumes of the segments formed by the heads are equal, as in Fig. 5. The volume of such a tank will be the same as that of a cylindrical tank with flat heads and whose length is the distance between the bases of the segments formed by the heads, because the increase of volume due to the bumped head is equal to the decrease of volume due to the dished head.

Hence, the volume of Fig. 5 will be

$$3^2 \times 0.7854 \times 6 \times 1728 = 73,287.24 \ cu.in.$$

The volume of a cylindrical tank with two bumped heads such as Fig. 6, will equal the volume of the cylindrical part plus the volume of the segments formed by both heads. Let us calculate this volume.

The volume of the cylindrical part will be

$$42^2 \times 0.7854 \times 80 = 110,835.65 \ cu.in.$$

Using the formula for finding the volume of a single-base spherical segment, and substituting we have

$$V = 0.5236 \times 4 \left[(3 \times 21 \times 21) + (4 \times 4) \right] = 2804.4 \ cu.in.$$

This multiplied by 2 will give the volume of both segments, or

$$2804.4 \times 2 = 5608.8 \ cu.in.$$

which added to the volume of the cylinder, equals the volume of the whole tank or

$$110,835.65 + 5608.8 = 116,444.45 \ cu.in.$$

Examples for Practice

(1) A knoll back of a boiler house is to be removed to permit extending the boiler house. If the knoll is shaped like a single-base spherical segment and is 50 ft. in diameter by 20 ft. high, what will it cost to remove the knoll at $1.04 per cu.yd. (one cubic yard equals 27 cu.ft.)?

(2) The pressure tank on a hydraulic elevator system has bumped heads. The cylindrical part of the tank is 12 ft. long by 4 ft. in diameter, the altitudes of the bumped heads are each 12 in. What is the capacity of the tank in gallons?

⁂

Probably the most notable railway electrification project at the present time is about to be undertaken in connection with the suburban steam railways of Melbourne, Australia.

The system includes 289 track miles and, the potential selected is 1500 volts direct current. Among the reasons given for the selection of high-tension direct current instead of single-phase alternating current was that the motor-car equipment with the former is simpler; hence the maintenance will be less.

Power will be supplied from a central station at Yarraville, a suburb of Melbourne, in the form of three-phase 25-cycle current at 20,000 volts. It will be stepped down and converted into direct current of 1500 volts at 12 substations at various points on the system. The high-tension transmission is by underground cables from the power house to the substation in the central area and by overhead conductors carried on the same structures which carry the trolley wire. Roller pantagraphs will be used.

The complete system will represent an expenditure of about $12,000,000, and an American firm, the General Electric Co., has been awarded the contract for furnishing the rolling-stock equipment.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"It is hoped that some day one company and one plant will furnish all the heat, light and power in every city of the United States", says the "Wall Street Journal." Godfreys clinkers! this editor is some classy little optimist. Just as soon as this plant is ready to operate, Ignatius, we will tip you to the job as chief engineer. It ought to pull down good money, considering the responsibilities. In the meantime, hang on to your present job.

⁂

Soon it will no longer be necessary to have the structural formation of a dachshund to see around a corner. A Berlin engineer has invented a combination of photography and telegraphy "whereby a person can see what is going on thousands of miles away." Won't ever be popular with those of us who sit up nights with sick friends.

⁂

"To make two kilowatts grow where only one grew before," says "Electrical World," "is the purpose of the Society for Electrical Development." This body is big with purpose to extend the use of electricity for industrial and domestic use. Bully! It's a fine thing to be public spirited, even for a consideration, but—it would be interesting to know just how it intends to aid the development of the isolated plant.

⁂

Because of short coal weights, says the Interstate Commerce Commission, the retail dealers and consumers annually lose $20,000,000. Who gets it? Can't blame Hi Stack this time. Hi never even got a look-in on this huge lump of combustion product.

⁂

"Lend us a passive ear."—"Valve World."

We have a team of ears that are sound and kind, and fit for a lady to drive a whisper into, but unfortunately they won't stand without hitching. You can have almost anything else from us, neighbor, our lawn mower, a setting hen, our calabash pipe or our fuzzy hat, but our passive ear! We pray thee hold us excused.

⁂

More than one kind of "juice" may be run through a conduit. A Philadelphia merchant is said to have 600 12-in. lengths of tile ducts entering the wall of his wine cellar to serve as receptacles for wine bottles. Each piece of 12x4-in. conduit holds a quart bottle comfortably.—"Electrical World."

Any operating engineer who contemplates reconstructing his wine cellar is welcome to this tip.

⁂

As long ago as 1638, Spanish engineers proposed that a canal be dug across the Isthmus of Panama. If the interests of better and uniform boiler laws are under consideration as long as was the canal, some of us may lay upon the hillside, or perhaps there'll be a good working substitute for the boiler.

⁂

Govanovich Sneezardski, a Pole and an electrician, has had his name legally changed to Coffin. Except as a time-saving kink, wherein lies the advantage? The first seems but preliminary to the other. Ought to get this; sneezy enough if you work it out.

⁂

"For quiet service rendered," the City Club, of New York City, recently gave a dinner to that city's "faithful unknowns," men who solve problems without appreciation, shed their constancy and loyalty outside the spotlight's glare, and remain "unhonored and unsung." Some of us have to do it, and while the money compensation is mainly what we are after, there is still satisfaction in the thought that dollars and cents are not always adequate pay for what we do well and quietly.

⁂

Prof. Marx, of Paris, says the aim of his life is to "show how it is possible to be happy." This is a good long-distance aim, and ought to hit some marks. Having studied the matter to his satisfaction, the learned Marx declares that a man may be happy with a broken leg. To make it a sure thing, why not break both legs? Then the patient just couldn't kick; he wouldn't have a leg to stand on.

Sarco Water Temperature Regulator

The Sarco water-temperature regulator, Fig. 1, is actuated by the expansion of a sensitive liquid hermetically sealed within a chamber into which is inserted a flexible corrugated tube.

It can be arranged to regulate the temperature of water or any other liquid where a supply of steam or hot water is used to obtain the desired temperature within any given container. The apparatus has an adjustable regulating device by which any desired temperature within given limits can be maintained constantly. The internal construction of the apparatus is shown clearly in Fig. 2.

In installing the apparatus the thermostatic element is inserted in the tank or container, the temperature of which is to be regulated, and the valve is connected in the steam or hot-water pipe, opening or closing according to the temperature in the tank.

There are three principal parts to the regulator. The thermostatic element, which is inserted in the boiler or tank, the controller element, and the valve *K*, Fig. 2.

The thermostatic element *A* is a tubular receptacle containing a heavy hydro-carbon oil into which is inserted a piece of corrugated copper tubing, the length of which

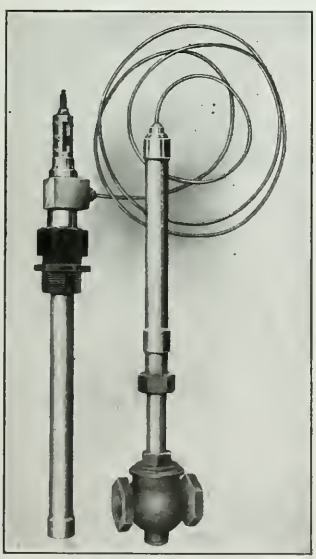


Fig. 1. Sarco Temperature Regulator

is extended or reduced by turning the regulator head *C*. From this thermostatic element a piece of fine copper tubing *D* passes to the controller *G*, which also contains a piece of corrugated tubing capable of compression when an increase of temperature causes the surrounding liquid in *A* to expand. The thermostatic element *A*, the connecting copper tube *D* and the controller *G* form a hermetically closed chamber. When the temperature increases in *A* the pressure increases and is transmitted to *G*, causing a compression of the copper tube *F*, which forces out the piston *I* and tends to close the valve *K*. The spiral springs *E* and *J*, operating in the opposite direction, tend to keep the valve open.

The regulator is simple and is capable of delicate adjustment, by increasing or reducing the space in which the expandable fluid is confined by extending or contracting the corrugated tube *B*.

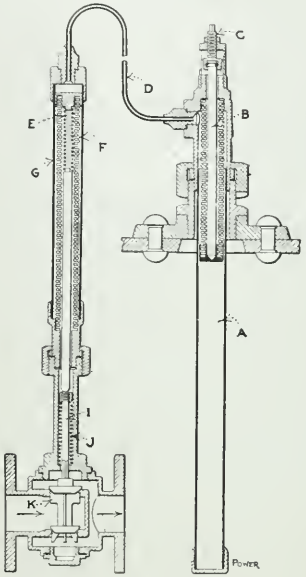


Fig. 2. Sectional View of Regulator

This regulator is made by the Sarco Engineering Co., 116 Broad St., New York City.

Lecture on Condensing Apparatus

Members and friends of the James Watt No. 7 Association of the N. A. S. E. listened to an interesting and instructive lecture on "The Care, Operation and Troubles of Condensing Apparatus," by Brother C. H. Bromley, associate editor of Power, at their quarters 307 West Fifty-fourth St., New York City, Saturday evening, Mar. 8.

After reviewing the types and purposes of condensers, the speaker emphasized the growing importance of condenser practice, especially in turbine operation, where high vacua are essential to economy. Mr. Bromley urged the engineers to be exceedingly careful in the operation of high-vacuum apparatus, as, because of its high initial cost, close attention was necessary to make it a well paying investment.

To assist in caring for the apparatus, a form of condenser log was shown (latern slide) which contained columns for half hourly readings of vacuum, load in kilowatts, and temperature readings of the inlet and outlet circulating water, hotwell, air-pump discharge, condenser steam inlet and condenser rear head. By keeping such a log, the speaker said, the operator could quickly locate the source of any condenser trouble.

Among the many views shown were some illustrating the latest design of marine wedge-shaped condensers, which are proving advantageous in reducing the effect of air in surface condensation.

As to packing for the tubes of surface condensers, the lecturer said that one large condenser manufacturer has adapted the fiber ferrule as superior to all others, when driven tightly into the stuffing-box.

Refreshments were served after the lecture.

NEW PUBLICATIONS

ELEMENTS OF HEAT-POWER ENGINEERING. By C. F. Hirshfeld and W. N. Barnard, Professors at Cornell University. Published by John Wiley and Sons, New York, 1913. Size 9x6 in.; 800 pages, illustrated, cloth. Price $5.

A very successful attempt is made to present in a single volume the essentials of engineering thermodynamics as well as the principles governing the design and performance of the various types of heat engines and auxiliaries.

In the first two chapters the definition and elementary laws of heat energy are presented. In connection with the laws of conservation of energy and the statement of the mechanical equivalent of heat, too much space is devoted to the discussion of the well known forms of perpetual motion. Under specific heat, emphasis is laid on the fact that the value for the mean specific heat should be used only in calculations involving the given temperature range.

The elements of steam and gas power plants, as well as the losses occurring during the transformation of heat into work are clearly explained and illustrated in chapter III. The insertion of a chapter of this character at the beginning is desirable as the understanding of the practical details should enable the reader to follow more easily the more complicated theoretical considerations in the subsequent chapters.

The laws of gases are treated in Chapters IV, V, VI and VII, and the fundamental principles of reversibility and entropy are taken up at considerable length. This is followed by a study of gas cycles, including the Carnot cycle, the Stirling and Ericson regenerative cycles, and the Otto and Brayton internal combustion engine cycles.

Chapters IX and X are devoted to the laws of vapors, mainly steam. The process of steam generation in a boiler is clearly illustrated and the steam table constants are deduced. Methods are also given for the construction of the temperature—entropy and Mollier, or heat—entropy charts.

The laws of vapors are applied in Chapter XI and XII to the study of thermal lines and vapor cycles. Comparisons are made of the Carnot cycle with gases and vapors. The authors then differentiate between the Clausius and the Rankine vapor cycles, the expansion being complete in the first case and incomplete in the latter case.

The definitions of power, efficiency and performance are taken up in Chapter XIII. The efficiencies discussed include the Carnot efficiency, the cycle efficiency, the indicated or cylinder efficiency, the mechanical efficiency, the thermal efficiency and the overall efficiency of a heat engine. Various methods of stating the performance of heat engines are given and graphical methods for representing them are outlined.

The theoretical steam engine is discussed; the difference between the theoretical and the actual steam engine being brought out also. The fundamental differences between various types of steam engines are very briefly outlined in Chapter XVII and this is followed by a consideration of governors in the next chapter.

In the chapter on valve gears the principles of the valve ellipse, the Zeuner, the Sweet and the Bilgram valve diagrams are explained. The effect of the angularity of the connecting rod is pointed out and a method is presented for correcting the various valve diagrams when short connecting rods are used. The necessity for compression to gradually reverse the pressure on the bearings and the effects of lead and early release are defined. The objections to the slide valve are indicated and the details of piston valves, multiported and balanced slide valves are illustrated. The peculiarities in the design of valve gears for high speed, medium speed and slow speed engines are then explained, including piston and balanced slide valves, independent cut-off piston and slide valves, and valve gears with oscillating valves with and without the trip cutoff.

Steam consumption curves for different methods of governing are presented and Willan's law, for the total steam consumption, is shown to hold true for engines with throttling governors. Tables showing the efficiencies and steam consumption of various types of engines are given.

Steam turbines are discussed in Chapter XXII, in which it is brought out that the thermodynamic problems in steam turbine design are centered in the nozzle, the conversion of the kinetic energy of the jet into work being a dynamic problem. The thermodynamics of the ideal steam turbine is considered, the effects of throttling and superheating being illustrated by means of the Mollier diagram. A diagram is also presented showing the relation between the available energy of the steam entering a steam turbine and that delivered by the shaft as useful work; this diagram also illustrates the various losses such as leakage, nozzle and bucket losses, windage, radiation and mechanical losses. The principle commercial types are then explained, and brief mention is made of the field of application of high and low-pressure turbine types.

Three chapters are devoted to internal combustion engines and the Otto and Diesel cycles are explained. Emphasis is laid on cylinder arrangements, carburetors for volatile fuels and vaporizers for heavy oils, methods of governing, gas and mixing valves, ignition systems, and the complete valve gear. Performance curves are also given.

Chapters XVII, XVIII and XIX are devoted to the consideration of fuels and combustion. The necessary air supply and the practical requirements for complete and smokeless combustion are explained. Grates, furnaces, stokers and burners for liquid fuels are illustrated.

Steam boilers are next taken up. The selection of a boiler is discussed and several representative types are described. In connection with the boiler performance, the authors express the equivalent evaporation both in terms of the old and the new values for the latent heat of evaporation. As the new steam table constants have been in use for the past five years, the insertion of the old values may only tend to confuse the reader.

Various forms of superheaters are next explained and means are cited for protection against the hot gases when steam is not flowing through the superheater. Draft apparatus is also described, including chimneys, steam jets and fans.

Gas producers form the subject of Chapter XXXIII. After describing the essential parts of gas producer plants the theory of the simple air producer is developed, and emphasis is laid on high temperatures, long time of contact between air, gas and hot carbon as a requirement for maximum efficiency. The practical considerations such as the caking of fuels and the fusing temperature of ash are shown to modify the theoretical requirements. Artificial cooling of producers by means of carbon monoxide and water vapor is then discussed, carbon monoxide giving a gas of more uniform composition, while water vapor is more economical. The effect of hydrocarbons in fuels, due to the formation of tar, on the practical operation of a gas producer is explained, and the cracking method of destroying the tar within the producer is illustrated.

Apparatus for heating feed water are considered and a chart is given showing the gain which can be expected. This is followed by a chapter on condensers and another upon water purification.

Chapter XXXIX is devoted to power plants and the items influencing the choice between the steam and internal combustion engine power plants are taken up.

The last chapters are devoted to a brief consideration of compressed air and refrigeration. Water injection, water jacketing and multistage compression with intercooling between stages are discussed.

In connection with refrigeration, the thermodynamics of the refrigerating machine is developed and the coefficient of performance explained. The air compression machine is described and its limitations illustrated. The fundamental principles governing the action of vapor refrigerating machines of the compression and absorption types are briefly explained.

In general the book is clear, original in the method of presentation and free from padding. The illustrations are good and aid in presenting much material in a short space.

BOOKS RECEIVED

THE GAS, PETROL AND OIL ENGINE. Vol. II. By Dugald Clerk and G. A. Burls. John Wiley & Sons, New York. Cloth; 838 pages, 5½x8¾ in.; 481 illustrations; tables. Price, $7.50.

GAS POWER. By C. F. Hirshfeld and T. C. Ulbricht. John Wiley & Sons, New York. Cloth; 198 pages, 5x7½ in.; 60 illustrations. Price, $1.25.

BOILER EXPLOSIONS, COLLAPSES AND MISHAPS. By E. J. Rimmer. D. Van Nostrand Co., New York. Cloth; 135 pages, 5¼x8½ in.; tables. Price, $1.75.

More Water for Power at Niagara

The Burton law, which expired March 4, 1913, was extended for another year by the House of Representatives on March 2, but withdrawn the following day by Senator Burton himself, states "Engineering Record." This removes not only the ban on the American diversion of water, but also that on the importation of power from Canada, increasing the latter from 160,000 to 250,000 hp.

About two years ago a treaty was signed between Canada and the United States, permitting the latter to divert 20,000 sec.-ft. of water from the Falls, but on account of the Burton law only 16,000 sec.-ft. were to be used at that time. The additional 4000 sec.-ft. now available will be split up between the Niagara Power Co., turning the wheels having been idle since the enactment of the law, and the Hydraulic Power Company. The diversion of this water through the power house wheels means an increased output in power of not less than 55,000 hp.

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Society of Superintending Engineers

The New England Society of Superintending Engineers, an organization of engineers recently formed in Boston by a number of men prominent in the engineering field, is composed of chief engineers, superintendents and master mechanics who have charge of large plants.

The objects of the society are to promote knowledge on all matters relative to the construction, operation and management of large power plants and their equipment which may be brought before it for consideration and discussion; to encourage social relations among its members; to aid each other either personally or professionally, and assist each other in a practical way in any matter affecting the members. The membership is limited to men who at the time of making application shall have actual charge of or the direct supervision of steam plants of not less than 2000 hp.

The officers are, president, George W. Walsh, chief engineer, central power station, Boston Elevated Ry. Co.; vice-president, L. H. Brown, chief engineer, Lynn power station, Bay State Street Ry. Co., Lynn; secretary-treasurer, F. L. Fairbanks, chief engineer, Quincy Market Cold Storage Co., Boston.

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American Engineers to Tour Germany

As announced in earlier issues, about two hundred of the most prominent mechanical engineers of the United States will go to Europe this summer to attend the fifty-fourth annual meeting of the Verein deutscher Ingenieure in Leipzig and to inspect the educational and industrial establishments of Germany. The object of the tour is to foster a broader commercial spirit between America and Germany.

The party will sail on June 10 on the Hamburg-American steamship "Victoria Luise," the largest and most superbly appointed cruising steamer afloat. Many friends of the engineers are also planning to sail on the steamer and will probably compose the entire passenger list. The official party will consist of 200 members of the American Society of Mechanical Engineers, accompanied by 100 ladies.

The program will include many features of interest. On arriving in Hamburg on June 21, the great shipyards will be visited. The party will then proceed next day by special train to Leipzig, where the King of Saxony will welcome it and the Verein deutscher Ingenieure will tender an official reception, at which the president of the American Society of Mechanical Engineers, Dr. W. F. M. Goss, will make the principal address.

The party will leave on June 25 for a tour of industrial Germany, visiting Dresden, Berlin, Cologne, Düsseldorf, Frankfurt, Heidelberg and Munich, including a trip up the Rhine.

Independence Day will be celebrated at Frankfurt under the auspices of the American Embassy.

SOCIETY NOTES

The spring meeting of the American Society of Mechanical Engineers will be held on May 20-23 in Baltimore. This city, with its remarkable harbor and nearness to Washington and Annapolis, is most attractive as a convention city.

At the regular monthly meeting of the American Society of Engineer Draftsmen, in the Engineering Societies Building, New York City, on Mar. 20, E. S. Houghton, a member, read a paper on "The Engineer Draftsman's Part on the Erie Barge Canal." A lecture, "The Application of Descriptive Geometry to Mechanical Drawing," by Frank Dempster Sherman, Ph. B., professor of graphics at Columbia University, was also given.

The Massachusetts Chapter of the American Society of Heating and Ventilating Engineers met in Boston, Mass., on the evening of Mar. 11 with a good attendance. The chief speaker was Frank T. Chapman, of New York, chairman of the committee on ventilation of moving picture places. A standard of laws governing such houses was discussed at length. Recommendations for legislation on minimum ventilation standards were adopted which called for a minimum of 3½ sq.ft. of floor area as a seating space per occupant, exclusive of aisles and public passageways; a minimum of 80 cu.ft. of air space per occupant, and that the quantity of positive supply of outdoor air be based on a minimum requirement of 15 cu.ft. per min. per occupant. The recommendations include measures for machine booth ventilation.

The program for the spring meeting of the American Society of Mechanical Engineers, at Baltimore, on May 20 to 23, has been tentatively arranged. The headquarters will be at the Hotel Belvedere and the professional sessions and social functions will also take place there. The program as now arranged is as follows:

Tuesday, May 20: 8 p.m.—Informal reception at headquarters.

Wednesday, May 21: 9:30 a.m.—Business meeting at headquarters. Regular session, with papers.

12:30 p.m.—Excursion to McCall's Ferry, dam and power house. Automobile trip, including ladies, with tea served at the Country Club.

Evening: Lecture at headquarters.

Thursday, May 22: 9:30 a.m.—Session on fire protection, at headquarters.

Afternoon: Trip over Jones' Falls conduits; inspection of sewage pumping plant; trolley trip to sewage disposal plant at Back River; exhibition of high-pressure fire service.

Evening: As guests of Engineers Club of Baltimore, the members will attend a reception and dance at headquarters.

Friday, May 23: Entire day to be devoted to a trip to Annapolis. At 2 p.m. address by Admiral H. I. Cone, A. S. M. E., Engineer-in-Chief, Bureau of Steam Engineering, U. S. N., at the Capitol.

PERSONALS

Joseph M. Burns has been appointed electrical engineer of the Morris County Traction Co., Morristown, N. J., in charge of power plants, transmission lines and overhead construction generally.

William McIlhenney, formerly assistant superintendent for the Keasbey & Mattison Co., Ambler, Penn., has accepted the position of chief operating engineer for the Ingersoll-Rand Co., Philipsburg, N. J.

Charles H. Garlick, for many years president of the National Association of Stationary Engineers, and one of the pioneers in the oil industry in Western Pennsylvania, was the speaker at the weekly luncheon of the Credit Men's Association of Pittsburgh, Penn., on March 6.

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The plant of the Warren City Boiler & Tank Co., Warren, Penn., was destroyed by fire on Feb. 24, with a loss of between $150,000 and $200,000. Five hundred men were thrown out of employment. The company will rebuild.

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Large users of coal will be interested in Bureau of Mines Bulletin No. 63, "Sampling of Coal Deliveries, and Types of Government Specifications for the Purchase of Coal," just issued. The federal government, which purchases $8,000,000 worth of coal annually, buys more than half of it under specifications and has gone deeply into the question of sampling and analyzing coal. George S. Pope, the engineer in charge of such investigations, is the author of the bulletin which may be had by addressing the Director, Bureau of Mines, Washington, D. C.

Progress of the World's Fair

Extensive preparations are under way for the international exposition to be held in San Francisco in 1915 to celebrate the completion of the Panama Canal. The Harbor View site has been reclaimed and cleared for occupancy, and the Service Building is nearing completion. The Machinery Palace, by far the largest of the buildings to be erected, will cover eight acres and contain 8,000,000 ft. of lumber, enough to floor the Exposition site three times over. The building will be one mile around and will have two miles of ornamental cornices.

Twenty-seven foreign countries and thirty-three states and territories have signified their intention to participate. President Taft urged Congress to appropriate $2,000,000 for a special building to house the administration exhibit. He also recommended such legislation as will facilitate the entry of material intended for exhibition and protect foreign exhibitors against infringement of patents and the unauthorized copying of patterns and designs.

New York has appropriated $700,000 for its participation while other states have appropriated from $100 to $50,000 to cover their preliminary arrangements. The Philippine government has appropriated $250,000 gold and Hawaii's commission has selected its building site.

Applications for exhibits have come from all parts of the world, the floor space for which amounts to 1,977,000 sq.ft.

W. D. A. Ryan, the illuminating engineer who devised the method of illuminating the Panama Canal and that of the Hudson-Fulton celebration, having experimented for several months, plans to make the illumination the most striking feature of the Exposition. One of the special features will be the introduction of jewels in the places of incandescent lights. The whole effect will be surmounted by a forty-eight electric scintillator—one for each state—which will be mounted off the main axis of the Exposition, about 500 or 600 yd. out in the water. It will be placed on barges anchored in the bay and require 60 trained men to operate the lights. These will go through many evolutions of color, and on clear nights will be visible for forty or fifty miles.

"The lighting of this Exposition," says Mr. Ryan, "will surpass anything in lighting in the world's history. The advance since the last big exposition in the science and art of electric engineering and development of electric apparatus has been so great that effects can be produced which were physically impossible five or six years ago."

Enormous Expenditures in Water Power Development

In developing inland navigation, says a recent bulletin of the Geological Survey, the federal government alone has expended $300,000,000, and prospective expenditures exceed this sum. It is obvious that the determination of stream flow is necessary to the intelligent direction of these disbursements.

In irrigation, the government is now expending on reclamation systems about $700,000,000, and this amount is far exceeded by private expenditures in the arid West. It is further obvious that the integrity of any irrigation system is based absolutely on the amount of water available. The largest use of water is that for domestic supply, and not only quantity but quality is of prime importance. In very recent years water power has become a matter of great national moment. Before the day of improved electric transmission, the importance of water power was confined largely to the locality at which it was generated, but now it is a public utility, and as the amount of water power available is dependent on the flow of rivers, the investigation of stream flow is a prerequisite to the intelligent management of this source of energy.

The drainage of the 70,000,000 acres of swamp areas of the country is a matter of water engineering, and the study of runoff is the first consideration in any drainage project. Drained swamp lands, as a rule, become the most fertile of agricultural areas, and the reclamation of the swamps of the United States should add a value which can be reckoned only in billions of dollars.

Flood prevention, both in the contributing areas and along the great lowland rivers, is the first necessity, as the flood damage in this country is probably over $100,000,000 annually.

A new heat indicator introduced by the General Electric Co. (Limited) consists of a paint for application to bearings or other parts of machinery and electrical apparatus, which normally is of bright vermilion, but on reaching a temperature of 120° F. shows a change of color and at 190 to 210° F. is almost black. When the temperature of the part falls below 120° F. the paint resumes its normal red color. It is claimed that the paint is practically indestructible, that it is unaffected by lubricating oils, that it prevents the formation of rust, and that the warning which it gives enables a machine to be stopped before any damage is done by overheating.—London "Times."

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared by the Worcester Electric Light Co., Worcester, Mass., for the construction of a new transformer station. Three 500-kw. transformers will be installed. Estimated cost, $20,000. R. W. Robbins is in charge of the work.

The Litchfield Electric Light & Power Co., Litchfield, Conn., is making preliminary arrangements for the installation of additional equipment in its plant. A. J. Fromholz is manager.

The New York, New Haven & Hartford R.R. Co. is considering plans for the construction of a power plant at New Haven, Conn., to supply electricity for the operation of the proposed electric line from New Haven to Boston. Edward Gagel, New Haven, is chief engineer.

The United States Light & Heating Co. contemplates the construction of another addition to its power plant at Suspension Bridge (Niagara Falls post-office), N. Y.

The Phillipsburg Light, Heat & Power Co. has been granted a franchise by the city council to construct and operate an electric-light plant at Phillipsburg, N. J.

Bids will be received by the borough clerk of Sharpsburg, Penn., until Mar. 27, for furnishing power-plant equipment as follows: Two 375-kw., 2300-volt, three-phase, 60-cycle generators, complete with exciters. Alternative bids on prime movers as follows: Two 450-hp. direct-connected type simple steam engines; two 450-hp. direct-connected cross-compound steam engines; two 375-kw. steam turbo driven alternating-current generating units; complete condensing equipment; three 50-light, four ampere metallic flame arc-lamp equipments complete; one four-panel switchboard complete. Sidney Martin, Penn Bldg., Pittsburgh, is consulting engineer.

The Andrew Ramsey Corporation, Mount Savage, Md., has been granted a franchise to construct and operate an electric-light and power plant at Ellerslie, Md.

SOUTHERN STATES

The city of Spencer, N. C., has been granted permission to issue bonds for $50,000, for the construction of a municipal electric-light plant and water system.

The J. B. McCrary Co., Atlanta, Ga., is preparing plans for the construction of an electric-light plant at Rochelle, Ga. W. C. Carter is city clerk.

The town council of Milton, Fla., is considering the proposition to issue $40,000 in bonds, for the construction of an electric-light plant and water system.

An expenditure of $400,000 is planned by the Tampa Electric Co., Tampa, Fla., for improvements including additions to its power plant and the installation of new equipment. J. C. Woodsome, Tampa, is local manager.

J. M. Riley has been granted a franchise to construct and operate an electric-light plant at Williamstown, Ky.

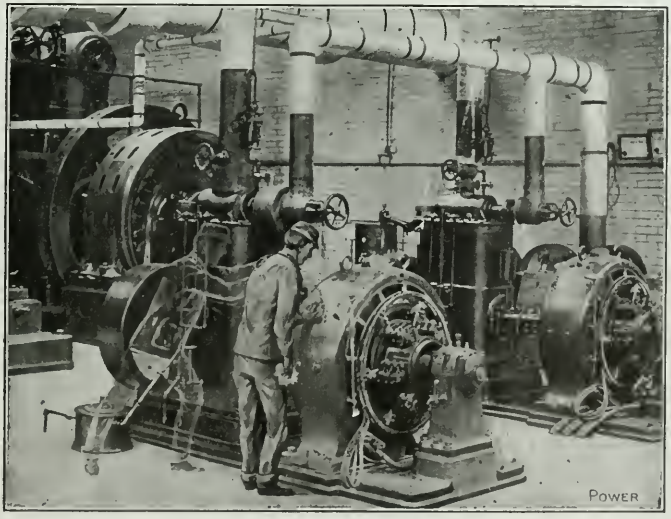
POWER

Vol. 37 NEW YORK, APRIL 1, 1913 No. 13

Forcing Oneself to Work

UNFORTUNATELY many men engaged in power plant operation are unfitted either physically, mentally or by temperament for the work. Others are not naturally qualified or do not possess the necessary training to make good operators.

Such men labor under either a physical, mental or nervous strain. Their work is not a pleasure to them. They lack enthusiasm and must force themselves to perform their duties. They soon fall into a rut and content themselves with a commonplace existence in the lower ranks.



Every man possesses certain qualifications which make him better suited for one line of work than for another. A young man just out of high school finds himself at the door of the power plant, seeking work. If he makes a fair appearance and if help is needed, he is given a chance, doing some unimportant task. If he is faithful and shows natural ability, he is advanced as his experience, training and conditions warrant. If his ability and trustworthiness are merely commonplace, he becomes a mere operator. If he shows no ability or liking for the occupation, he is discharged after a fair trial.

The same young man might have become the driver of a laundry wagon, a molder's helper or a house painter. His selection of occupation was haphazard, as was also his selection for the position.

That a man may get the most out of his work it must be congenial to him and he must be suited to it. To raise the standard of steam engineers it is necessary to raise the standard of the personnel. Every down-in-the-mouth, illfitting and illfitted stationary engineer lowers the general efficiency of the whole a corresponding amount. Any organization of workmen recognizing this fact and endeavoring to improve the standard of the individual workmen is bound to ultimately raise the standard of workmanship.

Many men are content to work in a half-hearted, indifferent manner, earning a mere living at work which is not attractive to them because their enthusiasm has never been aroused and they have never come to realize the value and importance of their work.

Important and well-paid positions are to be filled in the power plant field, and men having a vision of something beyond the doors of the engine or fire rooms will be chosen to fill the positions worth having.

If a man is physically unsuited to his work, he had better try something else. If he merely lacks enthusiasm he should get in touch with the various sources of inspiration, such as the national and local organizations and the leading technical journals dealing with the work. If he lacks training and experience, he had better get busy and be ready for the worth-while position when it comes.

Central Power Plant of Montgomery, Ala.

By Warren O. Rogers

SYNOPSIS—The main features of this installation are the manner of coal delivery, piping of the generating and auxiliary units and the design of the pump house, the latter made necessary by the great difference between the low- and high-water levels of the river.

In Montgomery, Ala., two electric-generating stations compete for the electrical business of the city. As a result, the rates charged for current are low.

What was known as the Citizens Electric Light Co. is now the Montgomery Light & Traction Co. Strange as it may seem, the rival electric company supplies the energy for the street-car service, this being one of the provisions of a long-term contract between the Citizens Electric Light Co. and the rival company. It seems, however, that this part of the contract has not been carried out and so poor was the service, that the new plant, described herein, was built by the traction company to not only supply electrical energy for commercial use in the city, but to also operate its own street-car lines. The matter is now being decided by the courts as to the validity of the contract, the traction company maintaining that it has been broken.

Power Plant

This new power plant is on the outskirts of the city on the bank of the Tallapoosa River, and has several interesting features. The boiler house is 175 ft. long by 75 ft. wide, and the turbine room is 100 ft. long by 110 ft. wide. The machinery is arranged in symmetrical order and so spaced that there is room to work on each unit without interference with the next. The building is in two sections, so to speak, the boiler room running at right angles to the turbine room. Between the turbine room and the

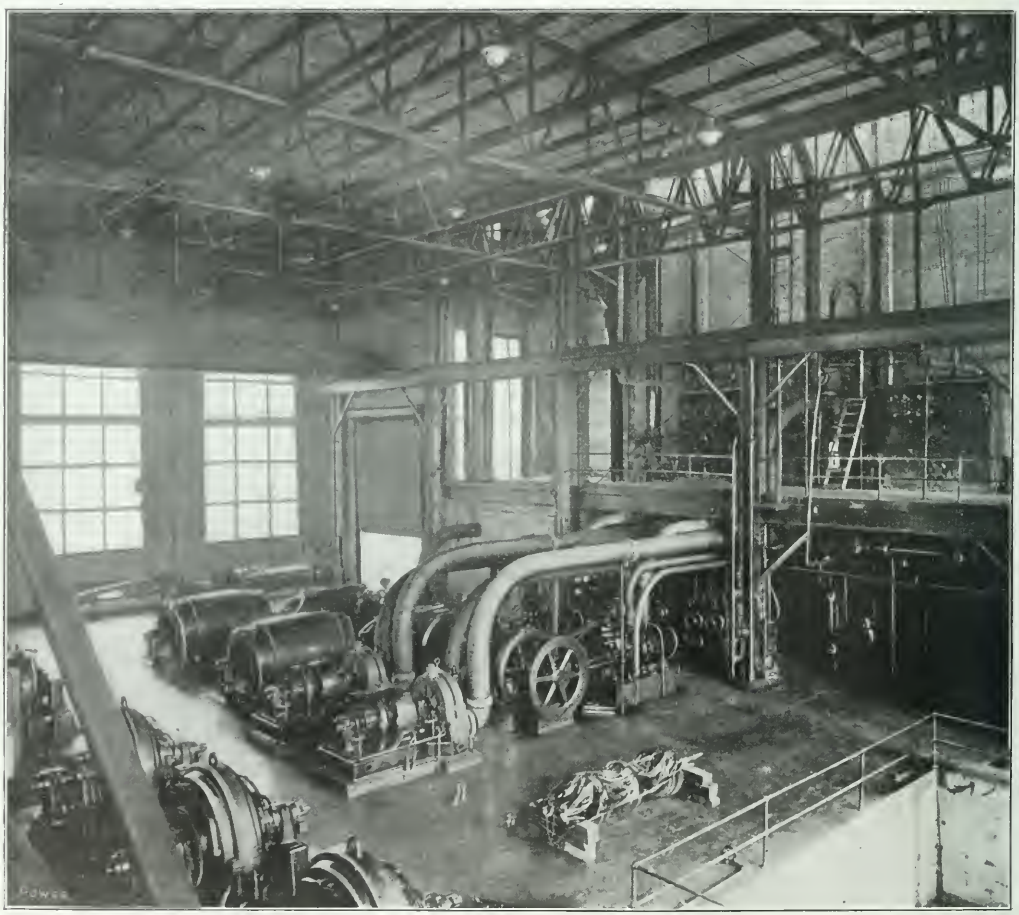


Fig. 1. View of the Turbine Room from the Switchboard Gallery

brick boiler-room partition is a gallery and pump bay. On the other side of the turbine room, is a second gallery and bay; both galleries running across the room. The floor of the turbine room slopes toward the center from four sides. A wide-gage track enters the turbine room at one side and crosses to the engineer's office, which is on the switchboard side of the room on the ground floor. A 20-ton crane runs the length of the turbine room and heavy material can be unloaded from the freight cars on the track and deposited at any desired point. A small 10-ton crane runs the length of the gallery next the boilers.

Generating Units

Two 2500-kv.-a. horizontal steam turbines drive the two 2500-kv.-a., 2300-volt, two-phase, 60-cycle generators at 3600 r.p.m. They are placed side by side with the steam end next to the boilers, as shown in Fig. 1. On the side of the room next to the generators, and between them and the switch-bay, are two 200-kw., 1200-r.p.m., rotary converters, changing the alternating current to direct current at 500 volts for power circuits through the city. There are also three 500-kw. rotary converters, running at 900 r.p.m., delivering 600-volt direct current.

Fig. 2. Pump House and Concrete Pit

Two turbine-driven exciters are at the end of the dry-vacuum pumps. The turbines are directly coupled to 100-kw., 125-volt, direct-current generators, of 800 amp. capacity, at 2400 r.p.m.

Condensing Outfit

On the turbine-room floor are two 10 and 24 by 18-in. steam-driven air pumps, which are piped to two barometric condensers placed next to the boiler-room wall. The exhaust connections from the turbines run under the floor to the condenser, as do the circulating-pump discharge pipes from the two condensers. As water in abundance is obtained from the Tallapoosa River, with an average temperature of 60 deg. F., the rise in temperature is but 5 deg. with a 29-in. vacuum. In fact, the water from the condenser is used to cool the oil used on the turbine bearings.

Pump House

Owing to the height to which the water in the river rises above the normal level, it was necessary to construct

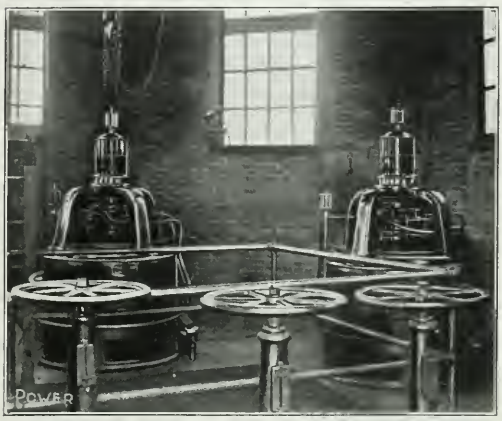


Fig. 3. Interior of Pump House, Showing Motors

a pump house and pit on the river bank. The pit is 65 ft. deep and 25 ft. in diameter. The lower part is round and built of reinforced concrete with 3-ft. walls. Above the concrete work the walls are brick and hexagonal in shape. The pump house is illustrated in Fig. 2.

The circulating pumps are at the bottom of the pit and are of 5000 gal. capacity per min. against a 100-ft. head, at low water, and 8000 gal. capacity per min. at high water. The variation in the level of the river between low and flood stages is about 60 ft. These pumps are directly connected to two 150-hp. induction motors, using 2200-volt, two-phase, 60-cycle current, and running at 1165 r.p.m. They are shown in Fig. 3.

An iron ladder extends from the floor of the pump house to the concrete bottom. Gate stands connect with the discharge-valve stems, which facilitate the operation of the valves. Beside the motor-control apparatus, there is a gage board, upon which are mounted eight gages for indicating the suction- and discharge-water pressures. At the back of the pump pit is a small counterweighted elevator used for lowering light loads to the bottom of the pit. A small motor-operated, four-ton, pivoted, single-arm crane extends from the wall of the pump house to the center, which can be moved to any position desired. Speaking tubes run from the top to the bottom of the pit, also to the switchboard gallery in the station. A railing surrounds the opening in the flooring over the pump pit.

Pumps

Except the two centrifugal pumps in the pump house, all of those in the plant are in the pump bay, which is under the condenser and heater gallery. They include

two 17 and 10 by 15-in. duplex, outside-packed pumps, used for boiler feed, and two 8 and 10 by 12-in. duplex pumps, used for house service and for pumping the hotwell water to the two 5000-hp. open heaters. The heaters are on the balcony above the pumps. Exhaust steam from the auxiliaries enters the heaters at the end, or can be bypassed to the atmospheric exhaust. The heaters can be operated independently of one another. The feed water is heated to from 190 to 200 deg. The locations of the pumps, heaters and condensers are shown in Figs. 1 and 4.

The latter illustration also shows the arrangement of the steam and exhaust piping, which is suspended from the gallery flooring. Steam from the boiler is conveyed to No. 1 turbine with a long and short bend at right angles to each other. No. 2 turbine is supplied from the header by a steam line extending from a tee to the turbine with a long-radius bend. The steam pipes to the dry-vacuum pipes are connected in a similar manner. The exhaust-steam lines connect with a 16-in. exhaust-steam header, which runs the length of the pump bay and connects either with the heater or with the atmospheric exhaust pipe.

Steam pipes, bent to the shape of a question mark, drop from the steam header to the pumps. This construction permits of free expansion and contraction. The peculiarity of the auxiliary piping is shown in Figs. 1 and 4. Both live- and exhaust-steam pipes are run in a

EQUIPMENT OF THE MONTGOMERY LIGHT & TRACTION CO.'S POWER PLANT

No	Equipment	Make	Purpose	Kw.	Phase	Cycles	Volts	Amp.	Hp.	Pres. lb.	Size	R.p.m.	Manufacturers
2	Turbines	Horizontal	Main units	2500						200		3600	Westinghouse Machine Co.
2	Generators	Alt. current	Main units	2500	2	60	2300	543				3600	
2	Converters	Rotary	Power circuits	200	2	60	500	333				1200	Westinghouse Electric & Mfg. Co.
3	Converters	Rotary	Railway	500	2	60	600	833				900	
2	Generators	Direct current	Exciters	100			125	800				2400	
2	Turbines	Horizontal	Exciters	100						200		2400	Westinghouse Machine Co.
2	Condensers	Barometric	Main units										Henry R. Worthington.
2	Pumps	Dry air	Condensers										
2	Pumps	Circulating	Cooling water			60	2200		150		5000 gal	1165	De Laval Steam Turbine Co.
2	Motors	Induction	Circ. pumps		2	60	2200	32	150			1165	Allis-Chalmers Co.
2	Pumps	Duplex	Boiler feed								17x10x15"		
2	Pumps	Duplex	House service								8x10x12"		Henry R. Worthington.
2	Heaters	Open	Feed water						5000				Harrison Safety Boiler Works.
8	Boilers	Stirling	Steam gen.						400	200			Babcock & Wilcox Co.
4	Transformers	Oil cooled	Station rotaries	100	1	60	2310-370						
6	Transformers	Oil cooled	Lighting	250	1	60	2310-370						Westinghouse Electric Mfg. Co.

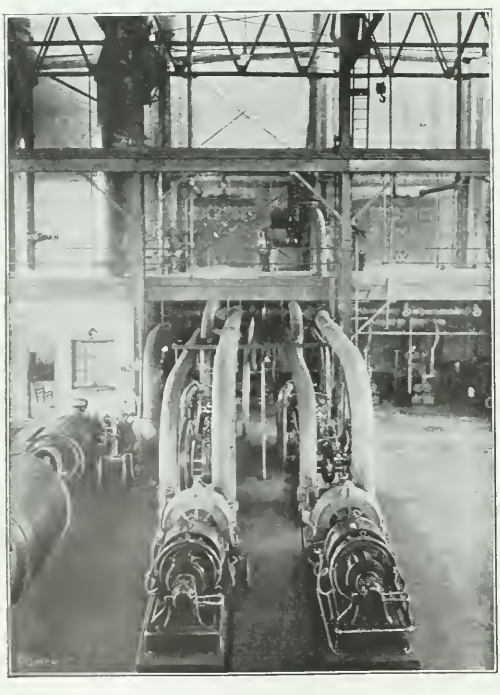


FIG. 4. SHOWING PIPING, PUMPS, HEATERS AND BAROMETRIC CONDENSERS

horizontal line at right angles from the headers, dropping down to the several units as shown.

BOILER HOUSE

Eight 400-hp., water-tube boilers, carrying steam at 200 lb. pressure are set in a row along one side of the boiler room. They are all equipped with superheaters, which increase the temperature 125 deg. Each boiler

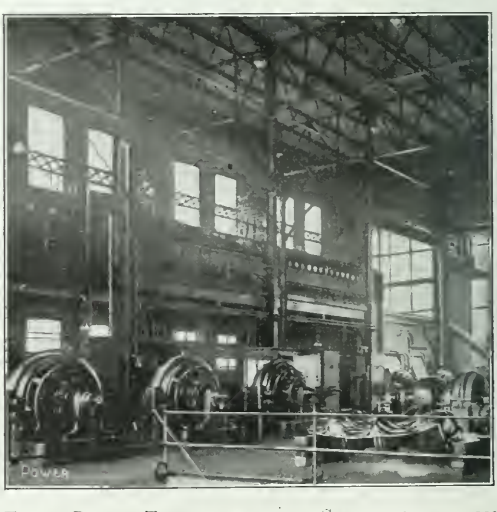


FIG. 5. ROTARY TRANSFORMERS AND SWITCHBOARD, FROM TURBINE FLOOR

to the 16-in. header through a 12 to 16-in. steam main in the boiler room. The steam-outlet pipes for the boiler connect with the header from the top with short-radius bends. The main header, above the pumps, is connected

contains 290 tubes, 3¼ in. in diameter, three 25-in. steam drums and one 42-in. mud drum. The main 16-in. steam main runs the length of the building, 18 ft. above the floor level and in front of the boilers above the firing

alley. It contains two U-expansion bends to relieve the pipe line of expansion and contraction strains. Feed water is supplied through a 6-in. main suspended under the steam main, branch pipes running to the several boilers.

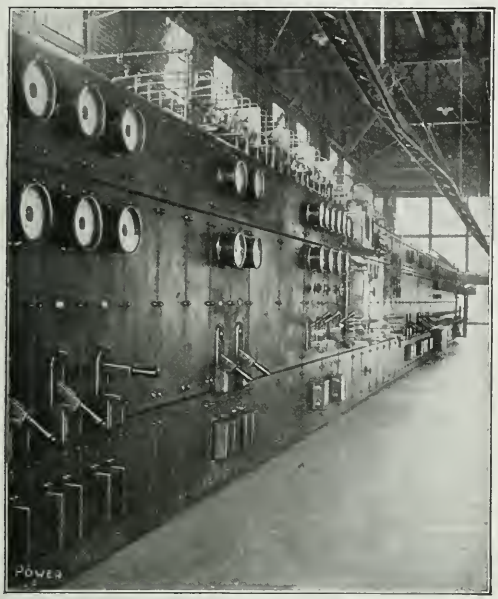


FIG. 6. SWITCHBOARD BALCONY

The grate area of each boiler is 6x14 ft., or 84 sq.ft. The furnaces are fitted with balanced doors, which are a protection to the fireman in case a tube bursts.

Coal is delivered to the boiler house in dongola coal cars and unloaded into a coal bin built with concrete partition walls and wooden sides. It has eight compartments and a total storage capacity of 480 tons. The concrete partition walls support a wide-gage track upon which the loaded coal cars are run to be unloaded. The boarded sides of the bin are high enough from the floor to permit coal to run down within easy reach of the fireman.

There is room for eight other boilers of the same size as those now installed, on the opposite side of the coal-storage bin. All smoke uptakes from the boilers enter a main smoke flue, which connects to a steel chimney 10 ft. inside diameter at the top, 25 ft. diameter at the bottom and 200 ft. high. At present, hand firing is used and the ashes are removed to the ashpit in front of the boilers, wheeled out and dumped at the rear of the station. Provision has been made, however, for an ash-handling system; an ash tunnel has been constructed and the ashpit made with a temporary bottom.

TRANSFORMERS

Along the side of the transformer-turbine room, next to the switchboard, are four single-phase transformers for station use. They are of 100 kv.-a. capacity, transforming from 2300 to 370 volts, 60-cycle current. There are also six single-phase transformers of 250 kv.-a. capacity, transforming from 2300 to 370 volts, 60-cycle, Fig. 5.

Above the transformer, suspended from the under side of the switchboard balcony, are the busbars. Below on the main floor are the oil switches and above on the balcony is the 58-panel slate switchboard, shown in Fig. 6. These panels are divided into groups, for the generating units, exciter units, motor and lighting units about the plant, instruments and commercial lights and motor-line control.

The plant is in charge of Chief Engineer J. M. Chumley, who has been with the company for more than 20 years.

❖ ❖

Determination of Steam Consumption

BY EARL B. SMITH

SYNOPSIS—A formula by which the steam consumption of a turbine or engine may be determined when exhausting into a jet condenser, having given the load, the condenser discharge and the steam and water temperatures.

❖

When a turbine or an engine is exhausting into a surface condenser, it is a simple matter to determine the amount of steam used. But when the exhaust is into a jet condenser, a great many difficulties are presented. The steam consumption in this case must be determined either by a careful boiler test or by computations from temperature and volume determinations at the jet condenser. In large lighting and railway plants the boiler-test method usually is not feasible because of the difficulty of isolating a part of the boiler plant for use on the test; then the drips, the leakage, and the auxiliaries usually offer other complications.

A determination of the steam consumption of a turbine or an engine from the condenser end, when the condenser is of the jet type, need not be very difficult. The following is a description of a method that may be used on turbine tests, which has been found by the writer to be very satisfactory.

In most cases it is more convenient to determine the amount of water discharged from the condenser. Of course, if the amount of injection water may be determined and also the amount of condenser discharge, then the difference in a given time gives the steam consumption. But usually the amount of condenser discharge is the only quantity that may be determined. Temperature readings of the injection water and of the condenser discharge must be taken at frequent intervals.

Let

W = Pounds per minute discharged from the condenser, which is the mixture of injection water and the condensed steam;

w = Pounds of steam per minute supplied to the turbine (wet);

$(W - w)$ = Pounds of injection water supplied to condenser;

H_s = Total heat per pound of steam, w, supplied; taking into account the quality of the steam ($= q + xr$);

H_w = Total heat per pound of condenser discharge;

H_e = Total heat per pound of steam exhausted from the turbine before entering the condenser;

h = Total heat per pound of injection water.

Then the fundamental formula obtained from the total heat relations is

$$(W - w)\ h + w\ H_e = W\ H_w$$

Therefore,

$$w = \frac{W\ (H_w - h)}{H_e - h} \qquad (1)$$

To make a practical formula of this equation other factors must be introduced which will account for the various losses of heat and work. Take the case of a 6000-kw. low-pressure Parsons turbine direct-connected to a 5000-kw. alternating-current generator running at 1000 r.p.m.

Let,

B = Brake horsepower of the turbine;

K = Load in kilowatts on the generator during test;

F = Bearing friction and windage of the turbine, which is approximately 1 per cent. of full load;

E = Efficiency of the generator; which is 97 per cent. at full load, 96 per cent. at ¾ load and 94 per cent. at ½ load;

L = Windage loss and brush friction of the generator in kilowatts, approximately 2½ per cent. of full load;

R = Heat units lost by radiation from the shell, etc.; approximately 1000 B.t.u. per hour per square foot of the shell (3000 B.t.u. per minute in this case);

S = Total steam consumption per hour = 60 w.

The difference between the heat received by the turbine and that exhausted represents the work done plus all the losses. Then

$$w\ (H_s - H_e) = 42.41^*\ (B + F) + R$$

and since

$$B = \frac{K + L}{0.746\ E}$$

$$H_e = H_s - \frac{42.41}{w}\left(\frac{K + L}{0.746\ E} + F\right) - \frac{R}{w} \qquad (2)$$

Substituting equation (2) in equation (1),

$$w = \frac{W\ (H_w - h)}{H_s - h - \dfrac{42.41}{w}\left(\dfrac{K + L}{0.746\ E} + F\right) - \dfrac{R}{w}}$$

Simplifying,

$$w = \frac{W\ (H_w - h) + 42.41\left(\dfrac{K + L}{0.746\ E} + F\right) + R}{H_s - h} \qquad (3)$$

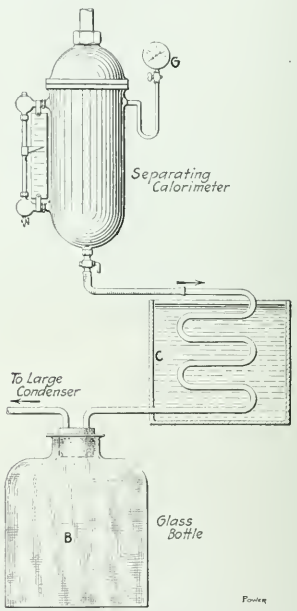
Then, since $L = 0.025\ K$ and $F = 0.01\ K$, substituting these and the numerical values indicated above, the following formula is obtained for the total steam consumption per hour at full load:

$$S = 60 \times \frac{\left(\begin{matrix} W\ (H_w - h) + 58.6\ K + (58.6 \times 0.025\ K) \\ + (42.41 \times 0.01\ K) + 3000 \end{matrix}\right)}{H_s - h}$$

$$= 60\,\frac{W\ (H_w - h) + 60.49\ K + 3000}{H_s - h}$$

$$= \frac{60\ W\ (H_w - h) + 3629.4\ K + 180{,}000}{H_s - h}$$

Formula (3) is applicable to the case of any direct-connected turbine or engine unit exhausting into a jet condenser. The method of determining W, the amount of condenser discharge, depends upon the installation. In some cases a carefully calibrated weir may be used, or a



METHOD OF COLLECTING CONDENSATE FROM CALORIMETER

pitot tube may be more convenient, or perhaps a venturi meter may be used.

The value of H_s the total heat in the steam received by the turbine, must be determined by a temperature or a pressure reading in the steam pipe, and a quality determination of the steam. This quality of the steam must be determined by means of a steam calorimeter. If the steam used is under the usual high pressures, then a throttling calorimeter may be the more convenient. But if the steam is low pressure (below atmosphere), then a separating calorimeter should be used. In the use of the separating calorimeter with low-pressure steam the small gage, G, ordinarily used for indicating the amount of steam flowing through cannot be used; but a small condenser made of a coil of copper pipe, C, immersed in a tank of cold water may be connected to the exhaust of the calorimeter. The condensate from this small condenser must be collected in a closed vessel

*The value 42.41 is the heat equivalent of a horsepower-minute.

B, which is connected to the vacuum side of the turbine condenser. Then, knowing the pressure of the steam (or its temperature) and its quality, x, the total heat may be computed by the aid of steam tables and the formula $H_s = q + x\,r$.

Formula (3) may be simplified somewhat further by dropping the items L, F and R, and thus obtaining the formula

$$w = \frac{W\,(H_a + h) + 42.41\left(\frac{K}{0.746\ E}\right)}{H_s - h} \qquad (4)$$

This formula (4) gives results sufficiently accurate for all practical purposes and which will be within 0.4 per cent. of those of formula (3). Also it may be noticed that when using formula (3) great accuracy is not necessary when selecting values for L, F and R. Even an approximate value of E may be used.

Talbot Water-Tube Boiler

By T. H. Heath

A water-tube boiler with features that will appeal to the engineer and power producer is becoming well known on the Pacific coast. Besides safety and economy, its strong points are reparability and freedom from scale. It is manufactured by the Talbot Boiler Co., Seattle, Wash. Its general construction is shown from Figs. 1, 2 and 3. Fig. 1 shows one of the smaller types of the boiler supplying steam to an engine-driven electrical unit.

The steam-generating parts consist of a number of steel headers at the back of the boiler from which water-tube members extend horizontally toward the front, each consisting of an outer and inner tube. The outer tubes are screwed into the header at the rear end, and are welded closed at the front or free end. The inner tubes, concentric with the outer ones, are also screwed into the header, but connect with a separate chamber; the other end is open and extends to within about six inches of the closed end of the outer tube. The tubes, as regards the headers, resemble a porcupine boiler, only the inner tubes of the Talbot boiler provide the circulating medium for the water, Fig. 5.

All headers, identical for each size of boiler, are set horizontally, one above the other, across the back, except the two lower ones, which are set vertically, or nearly so, directly below the horizontal ones. The tubes from the horizontal header extend over the furnace, but those from the vertical headers extend each side of the furnace. Fig. 1 gives a good idea of the arrangement of the headers and tubes, although the tubes on the firebox side are not shown, being covered by the insulating material. The front, or free ends, may be seen at the lower left-hand corner of Fig. 3.

The method employed for supporting the parts is shown in Fig. 1, although in later types the headers are carried by saddles and the water-pipe inlets by supporting legs. The free ends of the tubes are loosely supported by the front casing which allows unrestricted expansion. Iron-plate casing is used, with magnesia-asbestos insulation.

Referring to Fig. 1, the inlet is at the right end of the top header at A. By the inside arrangement of the header the water is compelled to go through all its tubes, and passing out through B, loops around under the casing and enters the next lower header at C. From this header and tubes the water passes out at D, crosses over to the right of the next lower one, through its tubes and thus goes through all of the horizontal headers.

From the last horizontal header the course is through the pipe E to the lower end of the left vertical header and, rising through it and its tubes, crosses over and enters at the bottom of the right vertical header at F, thence to the steam pipe G.

In Fig. 5 is shown a section of a header and the way the water is directed through the tubes. The water enters the chamber H through the ground joint and flows through the inner tubes which discharge near the outer

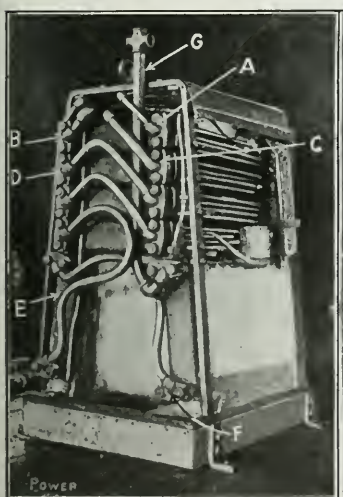


Fig. 1. Header Connections

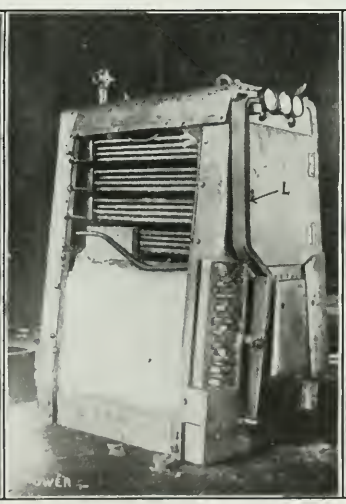


Fig. 2. Closed Tube Ends

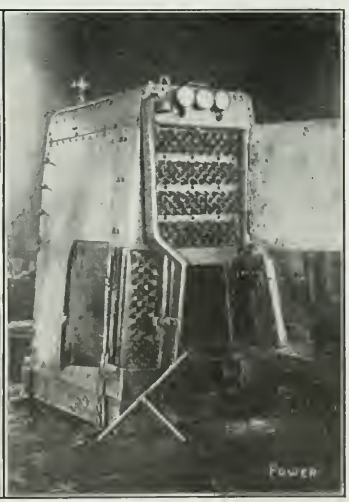


Fig. 3. End View of Boiler

end of the outer tube. The water returns between the two tubes to the chamber *K*, which passes it on to the next chamber connected with inner tubes only. Thus the water is directed back and forth over the heated zone, through four sets of tubes and headers.

It will be observed from Fig. 1 that the water-pipe connectors between headers are bent or looped upward. This is for the purpose of trapping or retaining the water in the headers when the boiler is not in operation.

The feed water is controlled automatically. The free end of one of the tubes is connected to a lever, and by its lineal contraction and expansion reduces or increases the flow of water by causing the lever to close or open a

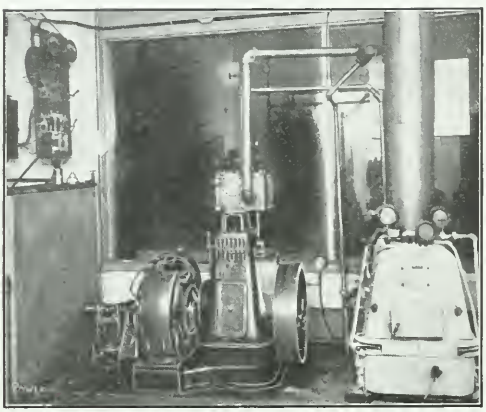


FIG. 4. BOILER AND ENGINE UNIT

piston-admission valve. An increase of temperature beyond a predetermined point expands the tube, causing the lever to open the admission valve, letting in more water; a lowering of temperature creates the reverse action to decrease the water supply. *L*, Fig. 2, shows the lever with the tube attachment. Water is delivered to the valve under constant pressure, generally from a pump, and bypasses the surplus back to the tank or supply; the same lever can be used to control the fuel oil when oil is used.

As the stack is directly over the top header tubes the feed water enters the coolest section of the boiler and works down into the hotter zone. Saturated or superheated steam may be used as desired. The degree of superheat is controlled by the water admission; reduction of flow causes an increase of superheat. The ordinary water gage or glass is not used in this type of boiler, the amount of water being indicated by a temperature gage—in appearance something like a steam gage.

There is only small steam-storage capacity in this boiler, as it is designed to generate steam as it is used. As a full head of steam can be raised from a cold boiler in from four to six minutes there need be practically no standby losses.

The headers are of crucible steel with cored tube chambers or passage ways and are tested to 1000 lb.; the tubes are of standard lap or butt-welded iron pipe screwed into the headers. On the small boilers, which have smaller pipes than the larger types, the inner tube is turned off on the outside, decreasing the diameter to give the proper clearance between them and the outer tubes. As they are subjected to a balanced pressure this does not interfere with the pressure capacity of the boiler. The ground joints between the headers and water connections, secured with studs, are shown in Figs. 1 and 5.

The rate of flow varies from a velocity of 3000 ft. in the smaller sizes to about 10,000 ft. in the larger types of boilers. The rapid circulation as well as increasing the heat-absorbing capacity also prevents pitting and formation of scale; boilers operated under working conditions after months of use are found unaffected.

Scale-forming solutions have been tried under normal conditions with the same results. The water is carried along so rapidly that there is no opportunity for the scale-forming elements to precipitate or adhere. In boilers freshly opened after service, the edge of the tubes screwed into the headers is found slightly rounded and polished by the rapidly moving sediment.

One of the important features of the boiler is its reparability. About the only thing that might possibly fail in the course of ordinary operation would be an outer tube; this could be considered an ordinary pipe-repair job. The free ends of the outer tubes are welded to standard shape to fit a spanner for screwing them in, and the inner tubes have a slot across the ends to fit a screwdriver arrangement; these operations may be done by opening the boiler front, when the tubes are at once accessible.

The casing is in renewable sections bolted to the supporting frame. Long fiber asbestos is pressed lightly over the tubes and the space between it and the casing is filled with magnesia.

As to safety, about the only thing that could happen would be a burst tube, and this would be no worse than

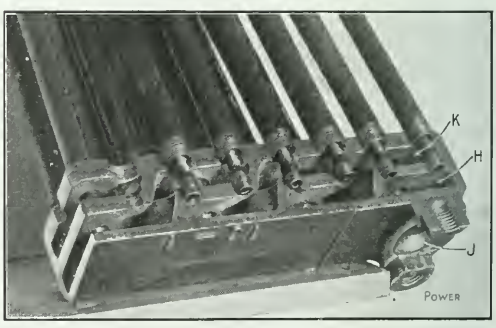


FIG. 5. DETAILS OF TUBE CONNECTIONS TO HEADERS

the bursting of a steam pipe, and there is no large volume of scalding water back of it. A header might let go, but this would be improbable, owing to its construction and large factor of safety.

Following is the result of a two-hour evaporation test that was made with a Talbot boiler rated at 100 hp.:

Water evaporated, lb.	7446
Oil used, lb.	490
Average temperature of feed water, deg. F.	97.4
Average temperature of feed steam, deg. F.	390
Average temperature of feed oil, deg. F.	65
Maximum stack temperature, deg. F.	350
Minimum stack temperature, deg. F.	265
Temperature of boiler room, deg. F.	70

The calorific value of the crude oil used was 18,500 B.t.u. per lb. and when corrected for moisture the test shows an evaporation of 17.31 lb. of water per lb. of oil.

The Rational Utilization of Coal

By F. E. Junge

SYNOPSIS—Inferior grades of coal which would hardly be worth transporting to industrial centers, are used at the mouth of the mines in coke ovens and producers. The gas is used in gas engines for producing high-tension electric current and innumerable byproducts are obtained from the tar residues. This practice is common in Germany.

As a result of geological retrospection and economic argument we are forced to the conclusion that all resources which are capable of utilization must be utilized, and that all values which are hidden in the soil must be recovered, in order to attain a desirable state of national efficiency. Especially coal, the greatest material asset of a country, should no longer be wasted by burning it on the grate, but, if it contains byproducts capable of recovery, it should be converted into its constituents, so as to yield the maximum possible returns in heat. Likewise, it is of great economic importance to utilize the large tracts of lignite and peat land, particularly those located near large undeveloped bodies of ore, and to render useful the inferior grades of coal, so abundant in mining centers. This may be done either by transforming the raw coals into some form of available energy which can be transmitted over long distances at reasonable cost, or by refining the low-grade coals into superior products, such as briquettes, coke, or chemicals, that they may serve as a basis for other industries.

The question which remains then is not whether the inferior grades should be used but how they can be used most efficiently. Before answering this question it is opportune first to get a clear idea of the meaning of the term "low-grade coal." There is no standard of designation which can be referred to and none that can be established. A fuel cannot be classified strictly by its relative heat value, nor by the volatiles it contains. The constant change in byproduct values or in the returns realized therefrom make it impossible to define clearly the limits below which a coal becomes inferior.

If, owing to their low carbon, high moisture and high ash contents, lignites and peat are referred to as low-grade fuels, traditional custom is being followed rather than plain facts based on recent developments. Likewise, there are conditions under which the screenings or smaller sizes of a high-grade lean coal may rank equal or lower in monetary value. It is only refuse such as culm and other waste, obtained in large quantities in coal mining and which hitherto escaped utilization entirely, owing to their excessive ash contents, that can be rightly classed as low-grade coals, since both their contents of fixed carbon and of volatile hydrocarbons is small.

For efficient utilization of coal there are now available the byproduct coke oven, the gas retort and the gas producer.

These have stood the test of practical experience and their exclusive adoption for the conversion of coal into superior products is no longer a matter of debate but of time and local consideration. The method of utilization depends on the heat value and chemical characteristics of the coal. The higher its heat value and the greater the transportation facilities available the larger will be the radius of commercial distribution of the coal from the pit. If the intrinsic value of the particular grade of coal is not high enough to pay its transportation charges it must be used on the spot, for the chief cost of coal at most places is not that of mining but of transporting it to the market. Hence, if by some mode of transmission either in the form of gas or electric current the transportation factor can be eliminated, the coal business is relieved of one of the chief factors which decrease profits, and prohibit commercial independence.

If the coal is of poor quality, such as culm, slack, refuse, screening and other waste containing a high percentage of ash, making it unmarketable, it may be convenient to discharge the screenings, without any attempt at their separation from dirt, slate, etc., upon a conveyor leading to the boiler room and use it for the generation of steam power. In some cases in Germany it is found that 30 per cent. of the mine output is worthless for selling, but if used at the mouth of the pit for generating electric energy, it is possible to sell power at a cost no greater than in a hydro-electric plant of the same size.

Sometimes, owing to excessive ash contents in culm and waste banks, these materials cannot be burned under boilers because the ash acts both as a diluent and as an obstruction to the combustion process. Nor can the materials be dumped back into the mines because of the danger of spontaneous ignition. Hitherto they were either stored in large piles in the neighborhood of the pit, or where territorial limitations prevented this, they were transported by rail into neighboring dumping grounds, being thus absolutely useless and causing heavy expenditure. Now there are two possibilities for using these low-grade coals. One is to dump them into Jahn's ring producers where their heat value is utilized. The 25 or 30 per cent. of combustibles in the culm yield a gas free from tar and well suited for heating, lighting and power purposes. A plant of this type has been in active operation for ten years in the von der Heydt coal mines, Saarbrücken, Germany. The cost of 1000 B.t.u. in the form of producer gas is only 0.005c. Or one brake horsepower-hour in gas engines costs 0.05c.

Another method was developed by Dr. N. Caro, of Berlin, Germany. It is based on the observation that culm banks and other waste contain more nitrogen than that which corresponds to their coal contents. In Westfalian collieries it was found that culm banks, the coal contents of which show on analysis of about 1.2 per cent. of nitrogen, contain up to 1 per cent. of nitrogen, although their total contents of combustible matter is only 25 or 30 per cent. Dr. Caro has succeeded in gasifying this material in producers of the Mond type, especially equipped for the purpose, and besides getting a suitable gas he gains about 80 per cent. of its total nitrogen contents in the form of sulphate of ammonia. At the same time, the sulphur is removed so that the residues of the gasification process can be directly dumped from the producer back into the mines without fear of causing ignition. From 60 to 90 lb. of sulphate of ammonia are gained per ton

of culm so that not only the cost of removing the coal is recovered, but a good profit is also realized.

There are places where coal of very small size is available in large quantities and at low cost, such as coal dust in coke and gas works. Their high ash and dust contents and the small size makes them unfit for boiler fuel, because the fine dust clogs up the flues and necessitates frequent cleaning. Nor are they suited for transportation. Two ways for utilizing these coals are now open. One is to burn them in especially designed gas producers, the other is in briquettes.

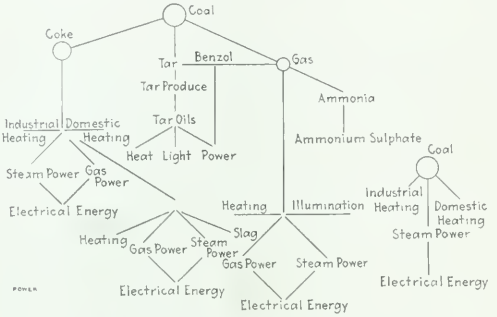


Fig. 1. Comparison between Commercial Possibilities of Burning Coal in a Boiler and Its Gasification in Coke Ovens

There are some points to consider when using dust coals in gas producers. The great resistance offered to the passage of the air must be overcome by keeping the charge as low as possible and uniform in height; otherwise the air will pass up along the walls, producing clinkers and a bad quality of gas. The coal must be charged frequently within short intervals and in small quantities, and if it contains moisture it must be preheated by the gas. This exchange of heat will increase the calorific value of the gas, at the same time lowering its temperature.

Under certain local conditions the smaller sizes, such as buckwheat, pea, dust anthracite, and dust coke, have a reasonable chance of competition and may even be superior to bituminous coal, lignite and peat fuels. For example, in a certain city gas power was to be adopted, and there were three different classes of fuel available, anthracite nut at $5 per ton, anthracite dust at $1.70 per ton, and lignite briquettes at $2 per ton, having the respective heat values of 13,500, 12,600 and 8100 B.t.u. per lb. The fuel consumption, including all losses, worked out at 0.25, 0.089 and 0.18c. per b.hp.-hr. for the three classes. In this particular case dust anthracite was superior, and it had the special advantage over lignite that it yielded a gas absolutely free from tar. Taking into consideration the factor of transportation it was found that the cost of fuel for operation with these three classes is equal when the plant is located at the following respective distances from the mine: anthracite nut 0, anthracite and coke dust 404, and lignite briquettes 73 miles. It is seen that dust coke and dust anthracite, owing to their low price and comparatively high heating value, have the largest commercial distribution radius, in this case.

There are other cases where dust fuels cannot be disposed of at a profit and where it is better to convert them into a more convenient form of fuel by briquetting. In one case in Riga large piles of dust coke were available, which had been sold previously as filling material for ceilings, bringing 2.5c. per 100 lb., while coke in the larger sizes sold at 30c. Although the dust coke contained from 75 to 80 per cent. combustible it was unfit for use in boilers, because of the objections previously mentioned. Therefore, a briquetting machine was installed which produced 1000 briquettes per hour. An addition of 5 per cent. of hard pitch and tar residues as binding material gave sufficient cohesion. The average production in a 10-hr. day was 8240 lb. of briquettes having a heat value only 5 per cent. lower than the coke, the higher ash content being compensated by the greater heat value of the tar and pitch. By the adoption of superior methods of utilization the returns from this low-grade material have been increased from 55c. realized per ton of coke dust to $3 received per ton of coke briquettes.

Summarizing, it may be said that coals of low heat value and others containing a high percentage of ash should be converted into electric energy at the mouth of the mine, the current being transmitted to neighboring districts, provided that there are markets within reaching distance. With the high voltages now employed there is, in small countries like Germany, practically no limit in distance, as far as the transmission of electric energy is concerned.

Coals of high heat value but of inconvenient form should

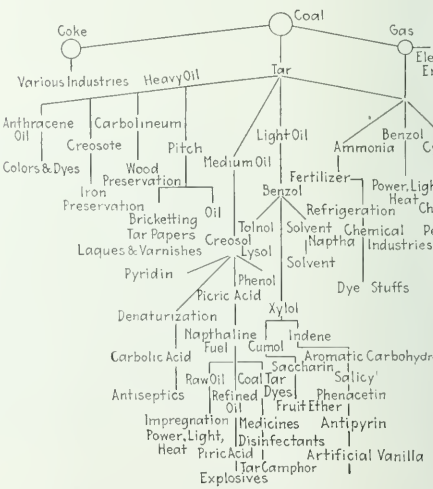


Fig. 2. Chart Showing Byproducts Recovered from Coal Tar

be either gasified in special producers and the power distributed by electricity, or they may be formed into briquettes, thereby increasing their value and rendering them capable of competition with the high-grade coals. Only those nonbituminous coals, such as anthracite and semi-anthracite, which contain a high percentage of fixed carbon and a low percentage of volatile hydrocarbons, and are convenient to handle, should be shipped to markets and used for direct combustion on the grate. Other conditions being equal, heat value and transportation fix a definite economic limit beyond which a certain coal from

a certain mine is no longer marketable and must be used at the mine.

The diagram, Fig. 1, gives a comparative analysis between the industrial possibilities inherent in the direct combustion of coal on the grate and in the gasification of coal in coke ovens. In the first case the application is limited to the generation of heat, steam power and electric energy. The applications in the second case are numerous and support a variety of industries; also the resulting coke can be used for heating, steam- and gas-power production and for the generation of electric energy. If used in the blast furnace for making iron it gives rise to a number of additional processes, the resulting blast-furnace gas being used for heating, power production and for the generation of electricity.

If the gas be deprived of its more valuable constituents there are obtained, among other things, sulphate of ammonia and sal ammoniac, which is used extensively in the manufacture of explosives and as fertilizer. The yield of ammonium sulphate amounts to about 1.5 per cent. of the weight of coal coked, and its price is about $60 per ton in Germany, or £12 ($60) per ton in England. Germany now controls the world's market with an output of more than 410,000 tons of ammonium salts, representing a selling value of over $25,000,000.

The second important byproduct of coke-oven gas, benzol, represents about 1.5 per cent. of the weight of coal coked. Benzol is used largely in the dye industries, but of late is also being employed largely as fuel for automobiles, its price being about $6 per 100 kg. (220 lb.) or 7½d. (15c.) per gal. in England. The French automobile business absorbs the largest part of the Germany benzol production. Benzol is the mother substance of a large number of aromatic compounds and of artificial dye stuffs; besides, it is used as a solvent and purifier for numerous organic bodies, such as caoutachouc and gums.

The work involved in the recovery of byproducts from coal tar, of which Fig. 2 presents a graphical idea, gives employment to an army of people, from the highly trained scientific expert and investigator, through the ranks of merchants, clerks and skilled laborers, down to the day laborer. The significance of the rational utilization of coal becomes even more apparent if some of the more important tar products are studied in detail. From one-fifth to one-fourth of the coal tar produced is used raw, the rest being subject to development by fractional distillation. The raw tar and such derivates as pitch-tar oil and creosote find extensive use as preservatives of wood and iron from dampness, decay and attacks of insects. Tar paper has now come to be, on account of its simplicity and cheapness, an indispensable building material for roofing and protection. Raw tar is also used to remedy the dust nuisance on roads, and as a binder for crushed stone it gives a smooth, elastic, noiseless, dust-free roadbed. Pitch is extensively used at coal mines as a binder for fine coal and coal dust, permitting these to be compressed into briquettes.

Conclusion

From the foregoing it appears that of all industrial resources coal is the most important material asset of a country. Its rational utilization enables a nation to possess within itself almost all the essentials of national supply, and the possibilities of further development are practically unlimited. To reach this desirable state of commercial independence and technical excellence it is essential to abandon the old wasteful method of treating coal as a fuel and utilizing its heat value only. It is necessary to consider coal as a raw material burdened with latent wealth, and to recover from it, as far as possible, the innumerable byproducts inherent in it. It is further necessary to concentrate the rational utilization of coal at mining centers, to cease transporting it in its crude form, but instead, after separating out its valuable constituents, to transmit it in some superior form of energy, either as gas or electricity, to the markets. By this method it becomes possible to make use of the inferior grades of coal which were hitherto regarded as worthless, at the same time eliminating the transportation factor and insuring maximum industrial efficiency.

How One Mill Beats the Central Station

"What is the situation with regard to the central station?" the editor asked a friend Down East one day. "Is the central station really selling current cheaper than the isolated plant can make power when there is heating to do?"

"Go down to the Lowell Weaving Co. and ask George Dearborn how he came out with it," suggested the friend.

The editor found Mr. Dearborn sitting in a sunny corner of the spick-and-span concrete office building of the weaving company. To my explanation of my interest in his experience with the central-station power, Mr. Dearborn responded, "The electric company here has a young fellow on its staff who can give out the most eloquent and convincing line of argument of anyone who comes in here, and the burden of his song is, 'uninterrupted service and unrivaled economy.' He was so charitably disposed, and so anxious and kind in his disinterested friendship for us that we came near dismantling our plant and hooking up to his feeder, in which case he assured us that our motive power and its worriments would be a thing of the past. We could sell one boiler, run the other at the 'minimum of pressure' (that was another of his pet phrases) and save enough so that we could almost afford to put him on the payroll.

"Well, we had to make a change. We had outgrown our little engine, and to take it out, cut out a bunch of concrete, make the plant over as I wanted to, and put in the bigger engine, would take, as I figured it, eight or ten weeks. So, we got some motors, hooked on to the central station, cast off from our worriments and prepared to glide down this placid stream of 'uninterrupted service and unrivaled economy.'

"We have developed here for the last five years some two or three hundred horsepower. We weigh our coal and take indicator cards four time a day. The coal bills at the end of the year check against the engineer's and fireman's figures and the indicator cards are still on file. Our bills for power averaged in the neighborhood of $26 or $27 a year per horsepower. We were generating power on from 2¾ to 3 lb. of coal per horsepower-hour, and the whole bill for power, including coal, engineer, fireman, oil, waste, repairs, etc., amounted to about $150 a week running under normal conditions. There were some students from the Massachusetts Institute of Technology who came

up here and made a continuous test for a week, and their figures check up with our own.

"Well, sir, there was not a single week out of the ten weeks that the central station was hooked up here that our power bill did not run from $575 to $600, and that's for the power alone. In addition to that we burned a lot of coal to keep the mill warm that would have been included in our little $150 a week when we were running our own plant. So much for the 'unrivaled economy.'

"Now, for the 'uninterrupted service.' We were shut down, three times, in that ten weeks, and I never could tell when we were going to get to going again. Once it was on account of a thunder storm; the other times, something else. We never knew when it was going to happen, and when it did happen, we never knew whether to send the help home or keep them around. If you telephoned, they could not tell you whether the current would be off for two hours or a week. Why, that little Rollins engine that we took out had run five years with only one shutdown to its account, and that was only for about three minutes while they took out a handful of waste that had got into the regulator gears. We have got them cased in on the new one. Come down and look at our little plant. There is not much of it, but it is turning out power about as cheap as any of them."

We went out through the mill and Mr. Dearborn stopped to show us some cotton duck that looked fine enough to make a ball dress of. When I said so, he replied that they had made some out of silk. They make all of the fine duck which is used for sails on the Herreshoff yachts in the international races. They made some which was used on the "Shamrock," too; but that is a secret, for everything on the "Shamrock" was supposed to be British made.

They have a nice, plain, work-a-day plant, with no frills, but with everything excellently adapted to its purpose, convenient to handle and made to give "uninterrupted service," without any spare units, duplicate parts or standby service. The floor of the engine room is a great monolith of concrete, to which is bolted a 24x42-in. Rollins engine running at 93 r.p.m., with 100 lb. initial pressure and a back pressure of from 3 to 4 lb. They use only about one-third of their exhaust steam. The National feed-water heater has ample capacity to heat the feed water nearly to the temperature of the exhaust.

The horizontal return-tubular boilers, of which there are two in place and another being installed, are right alongside the engine, separated only by a heavy wall, and the pipe is so ample and direct that there is little loss of heat or pressure between them. The boilers are 18 ft. by 72 in., with ninety-four 3½-in. tubes. All of the radiating surfaces are heavily covered with magnesia, for that is one of the points upon which Mr. Dearborn places especial stress. "Keep your heat in when you have got it; a little more covering will pay for itself in a little while, and then go on making money for you for years." The boilers are served by a concrete stack 100 ft. in height, with a 72-in. core and a draft, as Mr. Dearborn expresses it "which would snatch the fireman's shovel away if he did not hang on to it."

The engine is belted to a jackshaft with a heavy three-ply belt. If anything went wrong with that belt, or transmission, it would put the mill out of business; but nothing is expected to go wrong. "When I buy a belt," said Mr. Dearborn, "I ask the man the price and then I ask him if I pay him more can he make me a better belt." The belt that was on the engine ran the entire time that engine was in service, without any indication of trouble, and is now running one of the line shafts from the jack. The jackshaft is short and heavy, with ring-oiled bearings, and runs so smooth that, as my host expressed it "You could cool your drinking water on them." He is proud of the fact that the friction load of his mill is only 25 per cent. He uses nothing but turned iron shafting, put together with flange couplings, split wood-rimmed pulleys and ring-oiled hanger bearings. Turned iron shafting, he believes, gives less friction in the bearings and stays straight. The cold-rolled shafting, according to his doctrine, is filled with internal stresses. If you cut a keyway into it and relieve the surface tension, and especially, if you put it up with compression couplings, it will go all out of shape and will "look like a row of cornstalk joints waddling around." His shafting does certainly run so true that it is difficult to see whether it is turning. In the five years' service of the smaller plant, there was only one shutdown on account of the entire transmission. This was caused by a twister cord getting wound around the shaft and fouling one of the rings in one of the hanger boxes, causing it to heat.

The entire cost of the power plant did not exceed $14,500. It will be seen that even when the account is charged with a fair depreciation, interest, taxes, insurance, etc., upon the cost, there is an ample margin between the cost of the power so produced and that at which it could be purchased from the central station.

❖

Power Distribution for Panama Canal

The electric power distribution for the Panama Canal operation and lighting will require 246 miles of lead-covered cable, which is about 40 per cent. of the total amount placed by the largest electric power company in the United States during the 20 years preceding 1908, states *Engineering News*. These cables will be carried through the lock walls in vitrified clay ducts. On account of the large amount of cable to be placed in the ducts a special device using an electrically operated winch was resorted to.

Before the operation is begun the ducts are carefully cleaned. Then a small steel lead wire is pulled through, and by this means a manila cable is drawn through the duct. The electric cable is attached to the rope, and the winch is set in motion. By this method it is possible to pull 900-ft. lengths of No. 0000 B. & S. gage lead-covered cable at one time, whereas the average length by other methods is about 300 ft. The outside diameter of this cable is a trifle more than 2 in. In such a length the cable passes through two intermediate manholes, and is greased at three points to aid in reducing friction. The advantage of pulling the long sections at one operation is that the making of two joints is saved, and this is a considerable economy. The winch used for the purpose is mounted upon trucks operated over the return tracks of the canal towing system. The cable is placed directly below the floor of the operating tunnel, and, therefore, the pull by the winch is direct.

In addition to the amount of cable mentioned above, the lighting system will require about 112 miles of wire of miscellaneous sizes from Nos. 12 to 00 B. & S. gage.

ELECTRICAL DEPARTMENT

Generator and Prime Mover Capacities*

By D. B. Rushmore and E. A. Lof

The capacity of an alternator is limited not only by the actual load which it is carrying, but also by the power factor. The additional heating at low power factors and constant power is due to the wattless component of the armature current and also to the additional field current necessary to counteract it. In many cases it is possible to predetermine approximately the power factor under which the generators will operate, and a special design to meet this particular condition is largely desirable.

The generator may be designed for unity power factor, while the conditions of operation may give a power factor of 0.8, in which case only a part of the prime-mover capacity can be utilized. In some hydro-electric stations, the waterwheel is either too small or too large for the generator and a like result ensues. Where the generators are installed to handle peak loads, this maladjustment of ratings is a necessity, but with most of the larger systems it is unnecessary to run machines except at or near their maximum ratings. In the past every effort was made to adjust the ratings of generators to the load curves and 25, 50 and 100 per cent. overload guarantees resulted for certain apparatus. Experience and better load conditions have changed this to a maximum rating which has become possible largely through the growth in the size of stations and systems.

The speeds of engine-driven units, both gas and steam, have become nearly standardized, and turbine-driven sets are rapidly approaching the same condition. With waterwheel units, however, the situation is such that the capacity and speed of the generator are often determined largely by the hydraulic conditions and the characteristics of the waterwheel which is to be used.

With steam engines, the point of maximum efficiency is rather marked, and the ratings are usually such that the engine is working under its most economical load at the rating of the electrical generator. With gas engines, however, the efficiency increases with the load beyond the capacity of the engine, and for this reason, the rating of the engine is generally made as nearly as possible to its maximum capacity, leaving a small margin for regulating purposes. With the steam turbine the efficiency curve is usually so flat that it is a question of desirable overload capacity which limits the rating of the turbine. In the waterwheel unit, the efficiency usually falls off rapidly above and below the maximum point, so that the rating of the generator should correspond to the point of maximum efficiency of the waterwheel.

Steam engines and steam turbines are designed to operate with certain variations both in pressure of the steam and conditions of the vacuum. Gas engines must accommodate themselves to variation in the quality of the gas. With the waterwheels, however, most installations are subject to a change in head which varies over a wide range. In many of the low-head installations, the back water may bring about a change in head which is beyond the capacity of the wheel to accommodate, and in some plants additional wheels must be mounted on the same shaft and cut into service at times of low head. One particular instance of this kind is the plant of the Chattanooga and Tennessee River Power Co., where the head may vary from 20 to 42 ft. In most of the large developments, this change in head is the limiting feature in the design of the waterwheel as related to the generator capacity, for in all electrical work it is necessary that the speed of the generator be kept constant.

Waterwheel runners of different designs are compared on the basis of their specific speeds. The specific speed of a waterwheel is the number of revolutions per minute at the point of maximum efficiency that a similar wheel will give when it delivers one horsepower under one meter head. By comparison of the specific speeds, it is possible

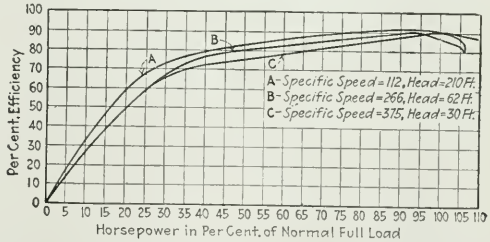


Fig. 1. Variation of Efficiency with Horsepower for Different Specific Speeds

to judge of the characteristics of waterwheel runners without respect to their actual speed, power or head. A high specific speed means a high actual speed and a low specific speed means a low actual speed in revolutions per minute. For this reason, waterwheels with low specific speeds are generally used with high heads in order to make the speed of the generator within the range of good electrical design.

The maximum full-load capacity of a turbine is that point beyond which the output decreases with an increase in gate opening. The margin between the point of maximum efficiency and maximum capacity depends upon the specific speed of the runner and is smaller the higher the specific speed. This is illustrated in Fig. 1, which shows that as the specific speed is increased the point at which maximum efficiency occurs approaches nearer to the power delivered at full gate opening. The specific speed may thus be increased to such an extent that the point of maximum efficiency and maximum output coincide. Therefore, with low heads and high specific speeds it is desirable to operate wheels near their point of maximum output, and to obtain the best results the generator should be designed with consideration given to this point.

*Excerpts from paper presented at midwinter convention of the American Institute of Electrical Engineers.

Referring again to the curves in Fig. 1, it will be noted that the full-load capacity occurs at about 6 per cent. above normal or rated full load in all three cases. This is in accordance with the general practice, the margin being allowed for governing. It is also noted that for curves *B* and *C* the efficiency falls off very rapidly at 6 per cent. overload, and that should the gate be opened still further, the output would reduce instead of increase. If, with wheels of low specific speed, as represented by curve *A*, the gates were still further opened, the power would continue to increase to some extent.

The point of maximum efficiency for wheels represented by curve *A* occurs at about 90 per cent. of normal full load, in the case of *B* at 93.5 per cent., while in the case of *C*, the maximum efficiency occurs just at the point of normal or rated full load. Thus, the power at which the maximum efficiency occurs approaches nearer to full load as the specific speed increases.

With high head wheels, as represented by curve *A*, the efficiency remains high over a large range in power, while for low head wheels, curve *C*, the efficiency falls off rapidly as the power is reduced below the normal full load. For this reason it is desirable to run low head wheels under practically full-load conditions. With high head wheels this is not so important. With wheels, as represented by curve *C*, it is also necessary to allow some margin above the normal full load for governing, as it is desirable to operate the turbine at its point of maximum efficiency. With high head wheels, curve *A*, such a margin need not be allowed.

The curves plotted in Fig. 1 represent operating conditions under constant head. In Fig. 2, is plotted a set of curves illustrating the effect of a varying head. A 10,000-hp. turbine is assumed to operate under a 32-ft. head, the speed being constant for a range of heads from 26 to 38 ft. As the head goes up to 38 ft., the shape of the curve approaches more closely curve *B* in Fig. 1, while, when the head falls to 26 ft., the speed being constant, it approaches more closely to curve *C*. In other words, when operating under a 38-ft. head the speed is lower than the best speed for the runner under that head; while, when operating under the 26-ft. head, the speed of the wheel is higher than the best speed. Under 38-ft. head the point of maximum efficiency is, furthermore, considerably below the normal full load at that head, while under 26-ft. head the power at which maximum efficiency occurs is the actual full load.

In the selection of a speed for any installation, therefore, aside from the cost of the generators, the question of the wheel efficiencies at partial gate openings has considerable bearing. Where a unit is likely to operate under a very wide range in power, it would be advisable to select a unit represented by curve *A*, giving a high efficiency for a considerable range in power.

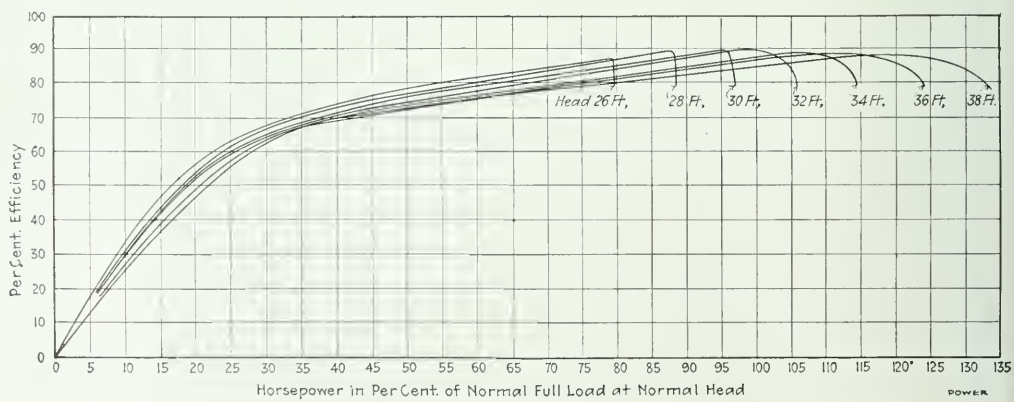
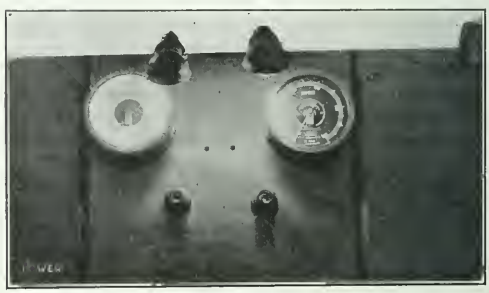


FIG. 2. PERFORMANCE OF 10,000-HP. UNIT AT CONSTANT SPEED AND VARIOUS HEADS

New Departure in Switchboard Meters

One of the elementary principles of scientific illumination is that only those parts should be illuminated that are desired to be seen. This principle has been utilized in a line of 7-in. dial, indicating switchboard meters recently put out by the Westinghouse Electric & Mfg. Co.



BLACK DIAL COMPARED WITH WHITE ONE

A white mark on a black background is much easier seen than a black mark on a white background, and, therefore, these meters are supplied with black dials, the markings on which are white. Their particular field of application is in installations involving poor natural or artificial illumination. The illustration shows the black and white dial meters under identical conditions of illumination, from which it is an easy matter to determine the relative readability of the two types.

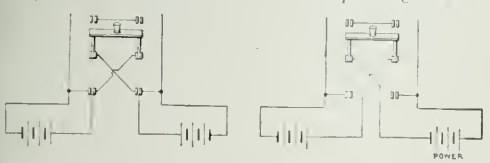
CORRESPONDENCE

Substation Wiring

In reading over Thomas G. Thurston's article on "Substation Wiring," in the Mar. 4 issue, I came across an error in Fig. 2. As printed the battery switch E is connected up wrong, which shows the two sections of the battery short-circuited at both the lower clips on switch E. But the main question still remains, even though switch E is connected up properly:

Where did the excess voltage come from, and why did the two signal lamps R and G burn? The excess voltage over the operating busbar voltage when the signal lights were put on the transformer system was due to the signal light circuit being placed in series with the low-tension side of the 10-kw., 2200- to 110-volt transformer by means of the auxiliary busbar. Such being the case, the transformer acts as a booster, hence adds a proportion of its positive electromotive force to that of the operating busbar.

When the switch E, Fig. 2, is closed up, current will flow through the green lamp and give excessive brilliancy, owing to increased electromotive force; thence through the auxiliary busbar and through the low-tension side of the transformer to the negative side of the battery or exciter, whichever is connected to the operating busbars.



As Fig. 2 Shows As Fig. 2 Should Be

Also current of normal transformer voltage will pass from the negative operating busbar through trip coil H and red lamp R to the auxiliary busbar and give normal brilliancy.

The reverse action will take place when switch F is closed down. Incidentally it may be mentioned that the direct current through the signal light and transformer circuit will be pulsating and unidirectional, and current will flow only when the positive transformer electromotive force is positive with regard to the operating busbars. Therefore, such current will pulsate directly at the rate of 60 per sec.

Ben Dawson.

Cedar Rapids, Iowa.

Commutator Trouble

I have noticed a number of communications in Power on commutator troubles and their causes, but think some of them may have been due to the same cause as some troubles I have experienced.

We have three 110-kw., direct-current generators, direct-connected to three-cylinder vertical gas engines; two of these units gave considerable trouble, the commutators burning in spots and the brushes sparking. All of the usual remedies were tried, but without overcoming the trouble. Some said the trouble was due to soft spots, because the burning always occurred in the same place; others said it was due to the armature winding being connected wrong because the burned spots were at equal distances around the commutator, but experts on armature winding could find nothing wrong. The real cause of the trouble proved to be something entirely different.

In making repairs to one of the engines, it was necessary to dismantle the engine and generator, and when they were being reassembled, I took careful note of every part as it was put in place. When the armature shaft was coupled to the crankshaft, I noticed it did not line up with the field polepieces; this set me to thinking. I found that the other unit was the same—about $\frac{3}{8}$ in. out of line. In the third unit, which had never given any trouble, the armature and poles were exactly in line.

The sub-bases of these generators are grouted in cement and it would have been difficult to move them; therefore I removed the field from the sub-base and cut out the bolt-holes to allow bringing the poles in line with the armature, and we have had no more trouble.

The engine cranks are set at 120 deg., and each of the burned spots was in the same relation to each of the crankpins. The connecting-rods had a tendency to hold the crank in one position, but the field was creating a magnetic pull against the connecting-rods and caused the brushes to spark at this point on each revolution of the commutator and this continuous sparking caused the burned spots.

I find it a good policy to wipe commutators off several times a day with a clean cloth, and to go over all brushes quite often, seeing that they work freely in the holders, that the contact points are free from copper, and that all other conditions are right.

H. H. Delbert.

Titusville, Penn.

Brushes Boiled in Mineral Oil

We have several direct-current generators and motors and have experienced the usual troubles with them; one 25-kw. machine in particular giving considerable trouble on account of sparking and roughing the commutator on heavy loads. Consequently, we had to sandpaper and turn the commutator very frequently.

About a year ago I read in Power about boiling the brushes in mineral oil. At first I hesitated to try it, as I thought it would gum up under the brushes; but having a spare set I finally tried it, and found that it worked to perfection. Whereas, the brushes had previously been emitting the usual destructive blue sparks, this changed to a thin streak of a dull red which followed around the commutator a short distance from the brush. After wiping off the commutator frequently for a day it ran cool without a spark. I now change and boil the brushes every two or three months, and have good commutation on this machine.

The effect on the brush by boiling is to soften it, and on a slightly rough commutator the rough places become filled with the carbon from the brushes; this carbon adheres and improves commutation, thus preventing sparking. Where there were several bars blackened and rather low, after a time they became polished and now as soon as the commutator gets the least bit rough I always boil the brushes and it effects a cure.

Brockville, Ont., Can. S. G. R[illegible].

GAS POWER DEPARTMENT

Heat Balance of a Gas Engine*

By Julian C. Smallwood

A complete economy test of a gas engine should include, besides the fuel consumption, the determination of the various losses so that their distribution may be studied. All of the heat energy of the fuel supplied must be accounted for in the form of useful work and losses. The equation between these quantities is called the heat balance.

The losses involved in the operation of a gas engine are mechanical friction, heat carried away by the jacket water, by the dry exhaust gases (sensible heat), by steam in the exhaust, by unburned gas, and stray losses, such as radiation, etc. It is convenient and logical to base the calculation of these losses upon one cubic foot of fuel gas under standard conditions of temperature and pressure. The heat balance may then be written, "Heat supplied by 1 cu.ft. of gas equals the heat from 1 cu.ft. turned into useful work plus the heat lost to friction, etc."

To measure the useful work, friction and jacket losses on this basis, it is necessary to meter the fuel supplied in a given time. The other quantities of the heat balance require the analysis of both the fuel and the exhaust gases. Generally, for the fuel analysis, a chemist's services are needed. Strictly speaking, a fair sample of the gas used during the test should be analyzed, but when the fuel is such as city illuminating gas which does not vary much from day to day, an average analysis is fairly representative and may be used without much error.

TABLE 1 PRINCIPAL CONSTITUENTS, IN PERCENTAGE OF VOLUME, OF GAS-ENGINE FUELS

"Low" means less than one per cent.

	Producer Gas Per cent.	Illuminating Gas. Per cent.	Natural Gas, Per cent.
Carbon monoxide, CO	25	15	low
Hydrogen, H_2	12	45	2
Methane, CH_4	2	25	95
Ethylene, C_2H_4 / Benzol, C_6H_6 / Heavy hydrocarbons	low	5	low
Oxygen, O_2	low	1	low
Sulphuretted hydrogen, H_2S / Sulphur dioxide, SO_2	low	low	low
Carbon dioxide, CO_2	5	4	low
Nitrogen, N_2	55	5	2
Higher heating value, B.t.u. per cu.ft.	150	650	1050

Table 1 gives the average composition of the principal gas-engine fuels. The analysis of the exhaust gases may be made with an Orsat apparatus. The chief constituents are CO_2, O_2 and N_2, but an analysis for CO should not be omitted. A determination of H_2 is desirable, but is not necessary if the CO is less than 1 per cent., as it is in proper operation. Since the CO is the least readily burned of the gas constituents, it is a fair assumption that the hydrogen and hydrocarbons are completely burned if the CO is nearly all burned, and experiment bears out this assumption.

Knowing the gas analysis, the weight of gases in the exhaust pipe per cubic foot of fuel supplied may be calculated from the formulas herein given. These are deduced upon the hypothesis that all the carbon in the fuel appears in the exhaust-gas analysis and that none other does. Contrary to this is the fact that some carbon is left as a deposit in the cylinder, but it is so small compared with the total carbon used as to be negligible. Also, if the lubricating oil burns, it will appear as CO_2 in the exhaust, so care should be taken that this condition does not obtain.

Other quantities, useful for purposes of comparison, that may be figured from the analyses are the number of cubic feet of air consumed per cubic foot of fuel and the "excess coefficient." The latter is the ratio of the former quantity to that required for complete theoretical combustion.

Sampling

If the fuel gas actually used on the test is analyzed, it is best to take a continuous sample covering the whole time of the test. This can be done by connecting a 5- or 3-gal. flask with rubber tubing to the gas main and siphoning water from the flask at a slow and uniform rate, thus drawing in the sample. The exhaust gas may be sampled the same way, but, if preferred, a number of samples covering equal lengths of time and taken at equal time intervals may be used and the results of their separate analyses averaged. A convenient method is to collect one sample while analyzing another, thus making a continuous operation. This has the advantage of showing the uniformity of combustion as the test proceeds. Snap samples should not be taken.

Duration of Test

This should last several hours, preferably, but, if on a small engine, a test of only one hour will give valid results, if the engine is previously run for 15 or 20 min. under the conditions to be maintained during the test. The readings to be mentioned later should be taken sufficiently close together to obtain a fair average. The useful horsepower should be maintained constant and other conditions kept as uniform as possible.

To show how a heat balance is derived the data from a gas-engine test will be worked through for the various results. Table 2 gives these data, and also the notation used in the formulas. The fuel used was illuminating gas manufactured in Syracuse, an average analysis of which is given in columns (1) and (2) of Table 3.

Fuel Consumption

Since the weight of fuel in 1 cu.ft. varies with the pressure and temperature, the gas-meter readings should be referred to standard conditions, namely, a pressure of 29.92 in. of mercury and a temperature of 32 deg. F. The following formula may be used. (See Table 2 for notation.)

$$V' = 16.4 \times \frac{B + \frac{P}{13.6}}{T_f + 460} \times V$$

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The barometer reading may be obtained in most cases from the nearest weather bureau; whereas, P and Tf necessitate the use of a water manometer and a thermometer at the point in the gas main where the gas meter is placed. For small engines, the usual gas meter may be used, or a gasometer, but for large sizes meters of the pitot, venturi or orifice type may be used. It is assumed that the reader is familiar with the methods of measuring brake and indicated horsepowers. When the engine is so large as to be inconvenient to brake, the

TABLE 2. DATA FROM A GAS-ENGINE TEST, AND NOTATION USED IN FORMULAS

B.hp = Brake horsepower	= 25
I.hp. = Net indicated horsepower	= 30.1
V = Cubic feet of fuel gas per hour by meter	= 414
V′ = Corrected to 29.92 inches of mercury and 32° F.	
B = Barometer reading, inches of mercury	= 29.5
P = Pressure of fuel gas above atmosphere, at meter, inches of water	= 4
F = Fuel consumption, standard cubic feet of gas per b.hp.-hr.	
Tf = Temperature of fuel gas at meter deg. F.	= 68
tj = Temperature of ingoing jacket water, deg. F.	= 61
Tj = Temperature of outgoing jacket water, deg. F	= 133
Te = Temperature of exhaust gases, deg. F.	= 750
t = Temperature of air near engine, deg. F.	= 70
Wj = Weight of jacket water, pounds per hour	= 1210
Wd = Weight of dry exhaust gas from the combustion of 1 cu.ft. of fuel, lb. per standard cu.ft.	
Wv = Weight of water vapor from the combustion of 1 cu.ft. of fuel, lb. per standard cu.ft.	
R = Ratio by volume of air consumed to fuel gas	
r = Ratio required for theoretical combustion	
X = Excess coefficient	
c, h, g = Sums of columns (3), (4), (5), Table 3, respectively.	
Volumetric Analysis of Exhaust Gas, Per Cents.	
D = Carbon dioxide, CO_2	= 9.0
O = Oxygen, O_2	= 8.8
M = Carbon monoxide, CO	= 0.5
H = Hydrogen, H_2	Not Analyzed
N = Nitrogen, N_2	= 81.7

useful horsepower may be approximated by subtracting from the indicated horsepower at the running load its value when the engine is running free.

Applying the data of Table 2,

$$V' = 16.4 \times \frac{29.5 + \frac{4}{13.6}}{68 + 460} \times 414 = 385 \; cu.ft. \; per \; hr.$$

From which the fuel consumption per brake horsepower-hour is

$$F = \frac{385}{25} = 15.4 \; cu.ft.$$

Heat Supplied

It is preferable to use a calorimeter to determine the heat in one cubic foot of the fuel gas, but if one is not available a working value may be obtained by calculation from the fuel-gas analysis.

The gas-engine code of the A. S. M. E. specifies that the "higher" heat value be used; that is, the heat obtainable from the fuel, including the latent heat of vaporization of the water formed by combustion of the hydrogen. Some authorities contend that the lower heat value is more logical to use in this connection since the gas engine cannot avail itself of this latent heat, but for the sake of uniformity the recommendations of the code will be followed.

TABLE 3. ANALYSIS OF FUEL GAS USED DURING TEST, AND COMPUTATION OF QUANTITIES USED IN FIGURING RESULTS

(1) Constituents of Fuel	(2) Percent by Volume	(3) Subscript of C×(2)	(4) Subscript of H×(2)	(5) Subscript of O×(2)	(6) Higher Heat Value of (1)	(7) (6)x(2)/100
CO	23.5	23.5		23.5	342	80.5
H_2	36.4		72.8		348	127
CH_4	15.3	15.3	61.2		1065	163
C_2H_4	6.9	13.8	27.6		1680	116
C_2H_6	3.9	23.4	23.4		4000	156
O_2	1.4			2.8		
CO	4.2	1.2		8.4		
N_2	8.4					
Total		80.2 = c	185.0 = h	34.7 = g		643 = higher heat value of fuel

To calculate the higher heat value of the fuel, multiply the higher heat value of each of the constituent gases, in B.t.u. per standard cubic foot, by its volume percentage, as shown by the fuel-gas analysis, and divide by 100. Add these products together: the sum is the heat value of the fuel gas. In Table 3, Column (6) gives the heat values of the combustible constituents. Column (7) gives the heat supplied by the amount of each constituent in 1 cu.ft. of the fuel gas used in the test under consideration. The sum of these, or the heat value of this fuel, is 643 B.t.u. per standard cubic foot.

Heat Converted into Useful Work

The heat equivalent of 1 b.hp.-hr. is 2545 B.t.u. Since the fuel consumed to produce this power is F cu.ft., the heat equivalent of the useful power per cu.ft. of fuel is

$$\frac{2545}{F}$$

Applying the data of the example this is

$$\frac{2545}{15.4} = 165 \; B.t.u.$$

Dividing this by the heat value gives

$$\frac{165}{643} = 0.256 \; or \; 25.6 \; per \; cent.$$

This is the thermal efficiency.

Heat Lost to Mechanical Friction

Friction horsepower = Indicated horsepower — brake horsepower

To base this upon the heat of 1 cu.ft. of fuel, a formula derived the same as the one last given is used, namely,

$$Friction \; loss, \; B.t.u. = \frac{2545 \times friction \; horsepower}{V'}$$

Applying the data of the example, this is

$$\frac{2545 \; (30.1 - 25)}{385} = 33.7 \; B.t.u.$$

or $33.7 \div 645 = 5.2$ per cent.

Heat Lost to Jacket Water

This is the heat absorbed in a given time divided by the fuel used in the same time. Considering hourly quantities,

$$Jacket \; loss = \frac{W_j \; (T_j - t_j)}{V'}$$

The weight W_j may be measured by a barrel or tank on a platform scales. The temperatures should be read with two thermometers, one in the discharge tank (provided the piping is arranged to discharge without material radiation loss); the other in a thermometer well in the inlet pipe or in a receptacle drawing water from a tap in the main situated similarly to the jacket as to temperature.

Applying the data of the example, the

$$Jacket \; loss = \frac{1210 \; (133° - 61°)}{385} = 226 \; B.t.u.$$

or $226 \div 643 = 35.2$ per cent.

Loss of Sensible Heat to Dry Exhaust Gases

This determination involves the measurement of the temperature rise of the fuel and air mixing with it, and of the weight of dry exhaust gases. For the specific heat, an average value, 0.245, may be used with sufficient accuracy. Then

$$\textit{Loss to dry exhaust gas} = 0.245 \times W_d \times (T_e - t)$$

W_d being the weight per cubic foot of fuel, obtained as follows:

$$W_d = \frac{c\ \{11\ D + 8\ O + 7\ (M + N)\}}{9000\ (D + M)}$$

The value c is obtained as shown by Table 3. The subscript of the C in each fuel gas constituent shown in Column (1) is multiplied by the volume percentage of that constituent as shown in Column (2). Column (3) shows these products, the sum of which is the value of c.

The weight formula is based on the assumption that the hydrogen and hydrocarbons are completely burned. Hydrogen in the exhaust, not analyzed for, generally produces but little effect on the weight of the exhaust gas since it is small in volume and density.

The temperature in the exhaust pipe should be taken by a high-reading thermometer (1000 deg. F.) inserted in a well filled with fine, dry sand, located as near the engine as possible.

Applying the data of the example,

$$W_d = \frac{80.2\ \{(11 \times 9 + 8 \times 8.8 + 7\ (0.5 + 81.7)\}}{9000\ (9 + 0.5)}$$

$$= 0.703\ \textit{lb. per cu.ft. of fuel}$$

and the loss to the dry exhaust gas equals

$$0.245 \times 0.703 \times (750 - 70) = 118\ B.t.u.$$

or $118 \div 643 = 18.3$ percent.

Loss to Water Vapor in Exhaust

Since the higher heat value of the gas is used, the latent heat of the water vapor should be included. It is then necessary to find the total heat of the steam in the exhaust gas above the heat of the liquid at room temperature. If the pressure of the steam were known, its total heat could be found by reference to the steam tables; but since the steam is only a small part of the exhaust gas, its pressure is very much less than that of the mixture and is inconvenient to figure. Professor Diederichs has proposed the following expression for total heat under these conditions which agrees substantially with the curve furnished by Professor Marks.

$$\textit{Heat loss to water vapor} = W_v\ (1090 + 0.46\ T_e - t)$$

W_v, the weight of water vapor from 1 cu.ft. of fuel, may be figured from

$$W_v = 0.000251 \left(h - \frac{2\ Hc}{D + M}\right)$$

The value h is found the same as c, as shown in Table 3. If hydrogen in the exhaust has not been analyzed for, the term $2\ Hc \div (D + M)$ may be neglected. The formula ignores the small amount of water vapor brought in with the air and with the fuel gas.

Applying the data of the example,

$$W_v = 0.000251 \times 185 = 0.0464\ \textit{lb. per cu.ft. of fuel}$$

and

$$\textit{Loss to water vapor} = 0.0461\ (1090 + 0.46 \times 750 - 70) = 64.3\ B.t.u.$$

or $64.3 \div 643 = 10$ per cent.

Heat Lost by Unburned Fuel Gas

Considering only carbon monoxide and hydrogen in the exhaust, this equals

$$\frac{3.45\ c\ (M + H)}{D + M}$$

If hydrogen has not been analyzed for, omit H from this expression.

Applying the data of the example,

$$\textit{Loss by unburned fuel} = \frac{3.45 \times 80.2 \times 0.5}{9 + 0.5}$$

$$= 14.65\ B.t.u.$$

or $14.65 \div 643 = 2.3$ per cent.

Heat Lost to Radiation, Etc.

This is found by subtracting from the heat value of the fuel the other quantities of the heat balance, as just found, or by subtracting from 100 per cent. these quantities expressed in percentages. The "unaccounted for" heat includes that used for pumping the fuel mixture into the cylinder if the area of the lower loop has been subtracted from the upper loop of the indicator diagrams. This quantity could be separately accounted for, but it is generally sufficient to include it in the friction loss as is done when the lower loop is altogether ignored, or to list it under radiation.

Applying the data of the example,

$$\textit{Loss to radiation, etc.,} = 643 - 165 - 33.7 - 226 - 118 - 64.3 - 14.6 = 21.4\ B.t.u.$$

or $21.4 \div 643 = 3.4$ per cent.

Cubic feet of air per cubic foot of gas. This may be figured from the following:

$$R = \frac{c}{21}\left\{\frac{D + O + 0.5\ (M + H)}{D + M} + \frac{h - 2\ g}{4\ c}\right\}$$

If hydrogen in the exhaust has not been analyzed for, omit H from the foregoing.

Applying the data of the example,

$$R = \frac{80.2}{21}\left\{\frac{9 + 8.8 + 0.5 \times 0.5}{9 + 0.5} + \frac{185 - 2 \times 34.7}{4 \times 80.2}\right\}$$

$$= 8.63\ \textit{cu.ft.}$$

Excess Coefficient

The air required for the complete theoretical combustion must first be figured. This is

$$r = \frac{2\ c + 0.5\ h - g}{42}$$

Applying the data of the example,

$$r = \frac{2 \times 80.2 + 0.5 \times 185 - 34.7}{42} = 5.2\ \textit{cu.ft.}$$

from which

$$X = \frac{R}{r} = \frac{8.63}{5.2} = 1.66$$

HEATING AND VENTILATION

Pipe Sizes for Forced Hot Water Heating

By W. L. Durand

In the design of forced hot-water systems, the most common method of determining pipe sizes is on the basis of some allowable velocity. A 20-deg. F. drop in the radiator is assumed and the total heat required divided by 20 will give the pounds of water required. Water at 180 deg. F. weighs 60.5 lb. per cu.ft. Hence, the pounds of water required divided by this figure will give the cubic feet per hour. This divided by the velocity will give the cross-sectional area of the pipe. Thus

$$\frac{\textit{Pounds of water per hour}}{60.5 \times 3600 \times \textit{allowable vel. in ft. per sec.}} = \textit{area of pipe}$$

This velocity is ordinarily made from 2 or 3 ft. per sec. to 8 or 10, the smaller values being used for branch connections and risers where they serve to compensate the rapid increase in frictional resistance with decrease in diameter of pipe. Then the friction head is computed on the basis of the layout determined by the above method, and, if it falls within the limits set, well and good. If not, it is necessary to use some other velocity and recompute the pipe sizes.

This method is long and does not give results in keeping with good engineering and, due to the rapid change in friction with varying pipe sizes, does not give a balanced system.

What would appear to be a more logical method of determining pipe sizes would be to fix the total friction head per 100 ft. and from the total length of the system determine the allowable friction head per 100 ft. If a radiation table is compiled between the size of pipe and friction head, it would be a simple matter through its use to determine the pipe sizes for any system. Then, the final result would be a definite friction head and a constant drop throughout the whole system and not a small drop in one part and a large drop in another, as with the method outlined above.

The accompanying table gives the velocity per second, the cubic feet of water per minute and the radiation based on 170 B.t.u. per sq.ft. per hr. and a 20-deg. F. drop for pipes from 1 to 10 in. and friction heads per 100 ft. from 1 to 5 ft. This table could be extended if the conditions required; but it will be found to cover a large part of forced hot-water work.

VELOCITY AND VOLUME OF WATER AND RADIATION FOR DIFFERENT FRICTION HEADS

Friction Head per 100 Ft. Length of Pipe in Feet

Size Pipe, in.		1	1¼	1½	2	2½	3	3½	4	4½	5
1	Vel.	1.21	1 36	1.50	1 75	1 96	2 16	2 34	2 51	2.68	2 83
	Cu.ft.	0 436	0 490	0 540	0 630	0.695	0.777	0 841	0 904	0 965	1 02
	Rad.	186	210	230	270	297	332	360	386	412	435
1¼	Vel.	1 50	1 68	1 85	2 14	2 41	2 65	2 88	3 09	3 29	3 47
	Cu.ft.	0 936	1 05	1.15	1 33	1 50	1.65	1 80	1 93	2 05	2 16
	Rad.	400	450	490	570	640	705	770	825	875	920
1½	Vel.	1 60	1 80	2.00	2 31	2.61	2 88	3.11	3 34	3 58	3 76
	Cu ft.	1 35	1 52	1.69	1 95	2.21	2 44	2 63	2 82	3 03	3 18
	Rad.	575	650	720	830	945	1040	1125	1200	1300	1360
2	Vel.	1.90	2 13	2 35	2 73	3 08	3 40	3 69	3 93	4 20	4 41
	Cu.ft	2 81	3 15	3 48	4 04	4 56	5 03	5 46	5 82	6 22	6 57
	Rad.	1200	1350	1490	1720	1950	2150	2330	2480	2660	2810
2½	Vel.	2 14	2 40	2 64	3 08	3.48	3 81	4 15	4 45	4 73	5 00
	Cu.ft.	4 28	4 80	5 28	6 16	6 96	7 62	8 30	8 90	9 46	10 00
	Rad.	1830	2050	2260	2630	2980	3260	3540	3800	4050	4270
3	Vel.	2 44	2 75	3 02	3 53	3 98	4 40	4 76	5 10	5 40	5 72
	Cu.ft	7 51	8 47	9 30	10 9	12 3	13 5	14 7	15 7	16 6	17 6
	Rad.	3210	3620	3980	4650	5250	5760	6270	6700	7100	7500
3½	Vel.	2 67	3 00	3 31	3 86	4 33	4 80	5 20	5 56	5 90	6 25
	Cu.ft.	11 0	12 4	13 6	15 9	17 8	19 8	21 4	23 0	24 4	25 8
	Rad.	4700	5300	5800	6800	7600	8450	9150	9800	10,400	11,000
4	Vel.	2 80	3 25	3 58	4 18	4 70	5 15	5 60	6 00	6.40	6 75
	Cu ft.	15 3	17 2	19 0	22 2	24 9	27 3	29 7	31 8	33.9	35 8
	Rad.	6530	7350	8100	9500	10,600	11,650	12,700	13,600	14,500	15,600
4½	Vel.	3 08	3 47	3 80	4 42	5 00	5 50	5 96	6 40	6 80	7 20
	Cu.ft.	20 4	23 1	25 2	29 4	33 2	36 6	39 6	42 5	45 2	48 0
	Rad.	8700	9900	10,800	12,600	14,200	15,600	16,900	18,150	19,300	20,500
5	Vel.	3 30	3 72	4 10	4 80	5 40	5 93	6 45	6 90	7.35	7 75
	Cu ft.	27 5	31 0	34 2	40 0	45 0	49 4	53 7	57 5	61 1	64 5
	Rad	11,750	13,250	14,600	17,100	19,200	21,100	23,000	24,600	26,100	27,500
6	Vel.	3 75	4 22	4 67	5 40	6 10	6 70	7 25	7 80	8 30	8 75
	Cu ft	45 1	50 8	56 2	65 0	73 5	80 6	87 3	91 0	100	105
	Rad	19,300	21,700	24,000	27,800	31,400	34,500	37,200	40,100	42,700	45,000
7	Vel.	4 10	4 61	5 08	5 90	6 65	7 30	7 90	8 45	9 00	9 50
	Cu.ft.	66 2	74 5	82 0	95 3	107	118	127	136	145	153
	Rad.	28,200	31,800	35,000	40,700	45,750	50,500	54,300	58,200	62,000	65,500
8	Vel.	4 38	1 92	5 43	6 35	7 15	7 85	8 50	9 15	9 75	10 4
	Cu.ft.	91 5	103	113	133	149	164	177	191	204	217
	Rad.	39,000	44,000	48,300	57,000	63,700	70,000	75,700	81,600	87,100	93,000
10	Vel.	5 02	5 68	6 25	7 25	8 20	9 00	9 75	10 5	11 1	11 8
	Cu ft	165	187	206	238	270	296	320	345	365	388
	Rad	70,400	80,000	88,000	101,500	115,200	126,000	137,000	147,000	156,000	166,000

The writer has not as yet in operation a forced hot-water system based on the above table, as it was only recently worked up as a possible improvement over the usual method. Any criticism of this method would be gladly welcomed.

A Mixed Heating System

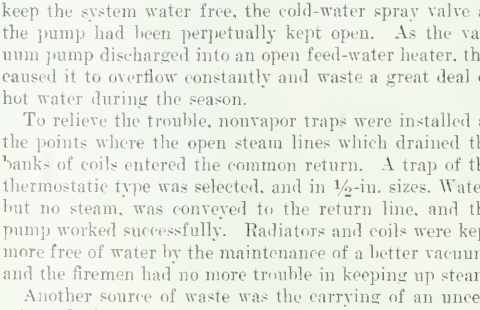
By Edward T. Binns

Some changes tending toward economy in the heating and power plant of a large philanthropic institution may

prove of interest. The plant was out of repair and much loss had been occasioned by the violation of certain basic rules at the time of installation.

One large administration building and a number of smaller buildings are heated and lighted from a central power plant. In the main building the indirect system of heating is employed for the three upper floors. An engine-driven fan, 3½x7 ft., delivers fresh air over some 8000 ft. of 1-in. pipe. These coils are heated jointly by the exhaust from the fan engine and a branch from the exhaust line which extends to all parts of the system. Two other houses are heated by indirect radiation, having engine-driven fans of proportionate size. Four other houses are heated directly and have radiators throughout. One vacuum pump must handle the water of condensation from all. The return ends of the radiators in two of the cottages are equipped with thermostatic traps. None of the drain lines from the fan coils were trapped, one being 2 in. in diameter and two 1¼ in. There were no traps on about 35 radiators in the main building and power house.

All returns from trapped and untrapped units were run to the vacuum pump by way of a common return line. As a result of this combination no end of trouble was experienced. Nothing could prevent steam from com-



Connection of Return Lines

ing back through the return line to the pump and destroying the vacuum. Besides, the various lines and heating units, being but poorly drained, gave continual trouble from leakage. Much trouble was also experienced from coils and radiators being short-circuited.

As an only recourse for producing vacuum sufficient to keep the system water free, the cold-water spray valve at the pump had been perpetually kept open. As the vacuum pump discharged into an open feed-water heater, this caused it to overflow constantly and waste a great deal of hot water during the season.

To relieve the trouble, nonvapor traps were installed at the points where the open steam lines which drained the banks of coils entered the common return. A trap of the thermostatic type was selected, and in ½-in. sizes. Water, but no steam, was conveyed to the return line, and the pump worked successfully. Radiators and coils were kept more free of water by the maintenance of a better vacuum, and the firemen had no more trouble in keeping up steam.

Another source of waste was the carrying of an uncertain and often excessive pressure in the exhaust line, and besides the waste from too much back pressure upon the engines, a considerable amount of steam and hot water was often ejected from the vent pipe of the feed-water heater. It might be mentioned that there was no feed-water thermometer, and that the back-pressure gage was not working. These two valuable adjuncts were speedily fitted up. Exhaust steam filled but a fractional part of the requirements, and it was necessary to use considerable live steam admitted through a reducing valve.

By replacing leaky blowoffs, broken globe-valve seats, worn and broken piston rings, etc., both the saving and satisfaction promise to be of substantial character.

Pressure Losses in Piping System*

The losses in the piping system are made up of two parts, the dynamic losses and the friction losses. The dynamic losses are due to changes either in the direction or velocity of the air flow and are composed of the loss of entrance and of the loss in elbows and connections. The first is the pressure required to produce velocity itself in the pipe and may vary anywhere from 1 to 1.5 times the velocity head, i.e., the pressure corresponding to the velocity, depending on whether the pipe is connected directly to the fan outlet or through the plenum chamber. It is expressed as a multiple of the pressure corresponding to the average velocity produced in the pipe. Where the velocity in the pipe is the same as at the fan outlet, this may still be considered a loss, in view of the fact that with a reduction of velocity through a gradually diverging outlet to a larger area, the difference between the velocity head at the fan and the velocity head in the pipe is largely utilized by conversion to static pressure.

The other chief source of dynamic loss is in the elbows and depends on the radius of curvature of the elbow and not on the size of the elbow or the velocity of the air. This loss may be expressed directly in per cent. of the velocity head, and, with a round, five-piece elbow, having a center line radius of one diameter, the loss will be 25 per cent. of the average velocity head. With a five-piece elbow, having a center line radius of 1½ diameters, the loss will be 17 per cent., or only two-thirds that of the first one.

The second source of pressure loss in the piping system is due to the friction of the air against the sides of the pipe. This loss will vary directly as the length of the pipe, or as the square of the velocity, and inversely as the diameter of the pipe. As the length is a fixed quantity for any system, the only factors subject to modification are the diameter and the velocity, which determine the relation between the power cost and the piping cost.

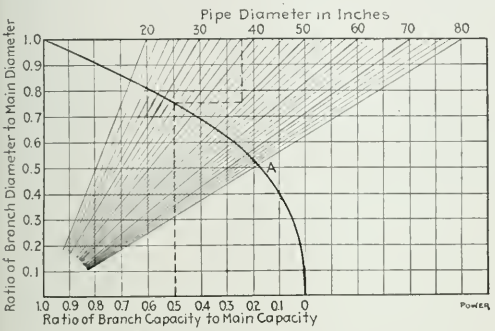
As in the case with the heaters, it is the usual engineering practice to proportion the piping arbitrarily, either from assumed velocities depending on the velocity of the air at the fan outlet, or, in better engineering practice, by determining the velocity which will give an assumed resistance considered suitable and within the fan capacity. It is the usual practice among fan manufacturers gradually to increase the velocity of the air in

*Latter part of paper on "Operating Cost of Indirect Heating Systems," by Frank L. Busey and Willis H. Carrier, read before the American Society of Heating and Ventilating Engineers. First part of paper appeared Mar. 18, 1913.

the main conduit, as the latter is decreased in size, owing to partial delivery of the air through branch outlets.

From the accompanying diagram, the sizes of the branches or reduced piping may be proportioned directly from the assumed size of the main pipe.

For example, assume a branch, intended to carry 50 per cent. of the capacity of the main pipe, which is 50 in. in diameter. Starting at the bottom of the chart with 50 per cent. capacity, pass upward until line *A* is intersected; thence, horizontally, to the diagonal line marked 50, and upward to the scale at the top of the chart, which gives a diameter of 38 in. for the branch



PROPORTIONING PIPING TO ALLOW FOR FRICTION

pipe. This is so proportioned as to give the same friction per foot of length as in the main pipe. This permits the resistance of the entire system to be calculated as though it was of one diameter, with a corresponding velocity throughout its entire length.

VELOCITY FOR MAXIMUM ECONOMY

A decrease in velocity increases the size and cost of the air conduit, but decreases the cost of power consumed in overcoming the conduit or piping resistance. From a point of economy, the question to be determined is, what relation between power cost and conduit cost, as determined by the velocity, will give the minimum annual total cost. This relationship is shown in the appendix to be

$$\left(\frac{V_m}{V_o}\right)^3 = 0.335\left(\frac{C_{wo}}{C_{po}}\right) \qquad (1)$$

$$V_m = 0.7\,V_o\left(\frac{C_{wo}}{C_{po}}\right)^{\frac{1}{3}} \qquad (2)$$

Where C_{po} and C_{wo} represent, respectively, the cost of power to overcome piping resistance and the annual allowance on the cost of the piping for interest and depreciation at an assumed velocity V_o, and V_m is the relative velocity required for maximum economy.

Comparing these relationships with those obtained for the heater, it is evident that they are almost identical. It may be seen, in this case, that, for the maximum economy, the annual cost of power consumed for piping resistance should be practically one-third of the annual interest and depreciation charges, based on the initial cost of piping.

PRACTICAL APPLICATIONS

For the purpose of illustrating the application of the foregoing principles to a system of galvanized-iron piping, different cases will be assumed and the results shown. A system handling 30,000 cu.ft. per min. at a velocity of 1950 ft. per min. will require a pipe 53 in. in diameter or an area of 15.32 sq.ft. These quantities will be taken as a constant condition, but different arrangements considered in the system of piping.

Assuming one straight duct, 200 ft. long and 53 in. in diameter, delivering all of the air at the end farthest from the fan, there will be two sources of loss to be overcome by the fan. First, the dynamic loss due to the velocity of 1950 ft. per min. (or one velocity head), and second, the loss due to friction, amounting to one velocity head in each forty diameters of length. The pressure due to the velocity of 1950 ft. per min. in the pipe, will be 0.237 in. water gage. The loss of pressure due to friction will be

$$\frac{200}{4.42 \times 40} = 1.13 \textit{ velocity head}$$

This loss expressed in inches of water will be

$$0.237 \times 1.13 = 0.257 \textit{ in.}$$

and the total loss will be the sum of these two, or 0.494 in. In the piping system, a part of the velocity is converted to static pressure, hence the power calculation should be based on total pressures with a corresponding fan efficiency of 50 per cent. At a rate of $20 per hp.-yr., the annual cost due to the piping resistance will be

$$C_{po} = 30{,}000 \times 0.000324 \times 0.494 \times 20 = \$96$$

A round, galvanized-iron pipe, 53 in. in diameter, would be made of No. 18 iron, weighing 2.3 lb. per sq.ft., and would contain 15.2 sq.ft. per running foot. This would make 32.7 lb. per running foot, or a total of 6540 lb. for the entire pipe. Allowing 25 per cent. annually for interest and depreciation on an initial cost of, say, 10c. per lb., the yearly allowance would be 2.5c. per lb. of iron. Then, the yearly allowance for interest and depreciation would be

$$C_{wo} = 6540 \times 0.025 = \$163.50$$

From equation (2) it may be determined that for the most economical conditions the velocity of the air in the pipe should be

$$V_m = 0.7 \times 1950\left(\frac{163.5}{98.0}\right)^{\frac{1}{3}} = 1620 \textit{ ft. per min.}$$

Assuming the case where the 30,000 cu.ft. per min. is to be uniformly distributed through a galvanized-iron pipe 200 ft. long, with equal openings every 20 ft. of its length, each discharging 3000 cu.ft. per min., will give an example of another common form of installation. Referring to the chart, it may be seen that, if the first 20 ft. of pipe is 53 in. in diameter, the next 20 ft., carrying 90 per cent. of the air, should be 51 in. in diameter. Treating each successive section in the same manner, its diameter and weight may be determined and the total weight of the piping found to be 3922 lb. Then, the yearly total allowance for interest and depreciation on the piping system will be

$$C_{wo} = 3922 \times 0.025 = \$98.05$$

The loss in pressure due to friction will be the same as in the first case considered, or 0.257 in., but the loss due to the velocity will be only about 40 per cent. of the loss, as calculated in the first example, or 0.095 in. The total pressure loss will then be

$$0.257 + 0.095 = 0.352 \textit{ in.}$$

and the annual power cost at $20 per hp.-yr. will be

$$C_{po} = 30{,}000 \times 0.000324 \times 0.352 \times 20 = \$68.50$$

The velocity for the most economical operation will be

$$V_m = 0.7 \times 1950 \left(\frac{98.05}{68.50}\right)^{\frac{1}{2}} = 1540 \text{ ft. per min.}$$

Another example of the application of the relationship herein presented would be to assume a case of an entire installation of fan, heater and piping. A fair annual allowance on the entire apparatus for interest and depreciation would be 20 per cent. on the first cost of the installation. Assuming that, in order to obtain the most economical operation, the yearly cost of power should be 30 per cent. of the above 20 per cent. allowance, makes the yearly power cost equal to 6 per cent. on the initial cost of the installation. Allowing $20 per hp.-yr. as the cost of power,† with a 25 per cent. allowance in the cost of the heater for interest and depreciation, the velocity through the heater should be approximately 590 ft. per min. in order to operate at the point of greatest economy.

For the same assumed conditions as to air handled, the resistance through the heater will now be 0.145 in., and at the most economical velocity through the piping system, the pressure loss will be 0.31 in., making a total pressure at the fan of

$$0.145 + 0.31 = 0.455 \text{ in., or } 0.254 \text{ oz.}$$

The total annual cost of power will then be $C_p = \$98$ instead of $212.50 under the first assumed conditions when using one straight run of pipe 200 ft. long. This would show a saving of $114.50. The total cost of the apparatus, as at first assumed, would be approximately $1331, so that the power cost of $212.50 would amount to 16 per cent. on the initial cost of the apparatus.

The total cost of the apparatus, as revised to meet the more economical conditions, would be $1660, or an increase of $329. The yearly cost of power would be 5.9 per cent. on the initial cost and there would be an allowance of 19.7 per cent. for interest and depreciation on the entire installation. The saving of $114.50 would make a return of 35 per cent. on the additional investment.

CORRESPONDENCE

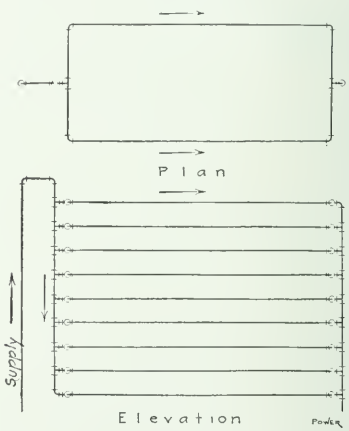
Circulation through Shunted Hot Water Radiators

On page 58 of the Feb. 4 issue of POWER, Mr. Brewster's explanation to the effect that the circulation is due to the cooling of the water in the radiator producing a difference of static head between the flow and return connections is entirely wrong. This would only be possible if the flow-supply connection was covered up to the point where it enters the radiator, which is not the case in practice. As a matter of fact, the flow connection would cool along with the radiator and there would be no flow at all if the radiator were connected to a tank as described. When the system is first started up and the radiator and both connections are full of water at room temperature, what is going to cause the water to start circulating if the circulation is due to a "thermo-siphon" action?

Mr. Brewster also states that the pipes should be so proportioned that the flow does not exceed 10 ft. per sec. The following is a list of pipe sizes with the friction head per 100 ft. of pipe, with the water flowing at the rate of 10 ft. per sec. This shows the large friction head that would result if this practice were followed. As a matter of fact, the best practice does not exceed 4 ft. per sec. in the smaller sizes of pipe:

Size of Pipe, in.	Head in Ft.
1	54
1¼	38
1½	32
2	23
2½	18 5
3	14 3
3½	12
4	10 5
5	8
6	6 4
8	4.7

Another point which is overlooked by a good many engineers in laying out hot-water work, and which is the case in the article under discussion, is that in order to equalize the system, the water in the supply and return pipes should flow in the same direction. If laid out this way, the difference in head is practically the same between the supply and return end of each loop. If laid



PROPER ARRANGEMENT OF PIPING

out with the flow in the opposite direction, the difference in pressure between the supply end of the first loop and the return end may be several pounds, while that between the supply and return ends of the last loop is only a few ounces. The illustration shows what is probably the best method of laying out the loop system, such as described by Mr. Brewster.

The reason for the circulation of the water throughout the risers and loops in this system is the same as for any other hot-water system, the difference in density between the water in the supply and the return risers. The circulation in the radiators is due to the difference in pressure or head between the supply and return end of the radiator, due to the friction loss in the main pipe or loop between these points. This applies equally well to either a gravity or forced system.

W. L. DURAND.

Brooklyn, N. Y.

The Hamburg-American Liner "Europa," sister ship of the "Imperator," is to be launched on Apr. 3, according to recent press dispatches. The "Europa" is 950 ft. long and has a beam of 100 ft.

†See curve B, Fig. 2, page 381, Mar. 18 issue of "Power."

EDITORIALS

Sleeping While on Duty

In this issue, page 461, a contributor tells of a night engineer who after heavily covering the furnace fire and adjusting the voltage and city water supply to the feed-water heater, would "turn in" for a few hours, leaving the plant in care of a street watchman, who came in hourly, if he was not delayed.

Those who have worked the night watches know how hard it is to resist the desire to sleep which is likely to come over one, especially between two and three-thirty in the morning. Some know, too, that it is an unforgivable offense for any member of the night crew to select a corner and sleep without first informing the man on watch of the particular corner selected. This is necessary to prevent delay in finding assistance should any be needed.

The above is typical of some men and plants. Needless to say it is wrong and the penalty should be immediate dismissal. There may be times when the offense is excusable, but such occasions are rare and, furthermore, the management should be such that it is never excusable.

It is such conditions as herein mentioned that make boiler and license legislation imperative.

⁂

Ammonia for Hot Bearings

Undoubtedly the discussion brought out by the letter in the Feb. 18 issue, page 234, on liquid ammonia for cooling hot bearings, will prove interesting.

The rapidity with which liquid ammonia absorbs heat while evaporating commends it for cooling hot bearings. But there is a possibility of cooling bearings and journals too quickly by its use, although as that depends upon the strength of the solution it should be possible to easily control the rapidity of the cooling process.

It should be remembered that rapid cooling of a bearing is only necessary until the temperature has been reduced below that at which the metal tends to become plastic. The aim is to prevent it getting so hot that the babbitt will melt or the brasses become badly "burred" or roughened and so accelerate the temperature rise due to increased friction.

Ammonia is dangerous and unpleasant to handle and for that reason it may never, among many engineers, become a popular means for cooling hot bearings. However, when an engine simply must be kept running, even though it develops a hot bearing, which all ordinary remedies fail to cool, an engineer would gladly use liquid ammonia, if he knew before hand that more serious trouble than a hot bearing would not develop as a result of using the ammonia.

The practice of using a paste composed of white lead, engine oil, graphite and ammonia to "wear down" a chronically hot bearing or pin is not uncommon when the bearing and rotating surfaces become hot because of abrasions on their surfaces. This paste is so effective, even when the ammonia content is small, that it ought to cool extremely hot bearings if the proportion of ammonia contained is increased.

Before applying liquid ammonia to a hot bearing one would like to know how strong a solution is best to use; if the bearings were of brass or bronze would the ammonia seriously corrode them? If so, what could be mixed with the liquid to offset corrosion but not impair the cooling properties of the ammonia?

We would be pleased to publish letters stating the results of actual experience with liquid ammonia as a remedy for hot bearings.

⁂

License Examinations

Quite frequently we receive letters inclosing lists of examination questions that have been asked applicants for engineers' licenses. In some instances the correspondents indicate a belief that if they could answer these particular questions they would have good chances of passing.

The purpose of holding examinations is to obtain evidence of the applicants' fitness for assuming the responsibilities that go with a license. While sample questions may be of value in suggesting the breadth of information and degree of intelligence covered by an examination, an applicant is likely to be disappointed if he has persuaded himself that preparation for an examination consists in simply uncovering correct answers to questions asked at previous examinations. The field of information in which a licensed engineer should be well qualified is so broad that only lame or lazy examiners would adhere to a stereotyped set of questions, hence memorizing answers to old ones is likely to be of little more benefit in preparing for an examination than committing to memory a table of logarithms.

An applicant should remember that the purpose of the examination is not to discover how well he can answer a list of questions pertaining to his work, but, rather, to find out how well he is versed in a knowledge of his work; not how well he can take care of a certain part of a plant, but how well he can care for the whole of it.

To many practical men, some questions asked by the examiners seem foolish or irrelevant. For example, "How many cubic feet of steam at atmospheric pressure weigh one pound?" Although the work of the operating engineer does not compel him to use steam tables very often, his answer to this question immediately indicates whether or not he knows of the existence of such tables and how to use them. The same applies to questions relating to finding the strength of boiler joints or the stress on flat surfaces supported by boiler stays. If the applicant can figure such problems, the examiner knows that he is quite familiar with boiler design and a desirable applicant.

Above all, the applicant should remember that to get his license he must show that he has a good knowledge of boilers and how to safely operate and maintain them. The rest of the plant equipment is secondary as far as his license is concerned.

Is It Worth While?

Routine work like the daily operation of a long-established power plant tends to raise a question in the minds of thoughtful and ambitious engineers as to the ultimate reward of faithful service. Is the game worth the candle when all its trying and wearisome tasks are considered and balanced against the pecuniary returns, present and probable, and the inner compensation which goes with duties well done?

In every field of human endeavor these times of questioning and of temporary discouragement now and then assail the most enthusiastic and energetic workers. Those on the inside of every occupation know that enduring success can only be secured by willingness to endure drudgery and a lasting determination to make each day's record measure a little closer to the highest standards. Thousands of men and women are forced to toil at tasks not of their own choosing to keep body and soul together; but the engineer who has the slightest interest in his work and the smallest natural aptitude for machinery has no excuse for numbering himself among these unfortunates.

The work of the engineer, in this wonderful century of power, covers so vast a field and touches the borders of so many unsolved problems that, in a sense, the money side of these useful and responsible occupations stands apart from their real interest. Happily the possibilities of large financial rewards encompass really distinctive and pioneer engineering work on all sides, but, to the man working for small wages, who has the imagination to see it, the study of his own special installation and the interest which it yields to intelligent analysis often equal the intellectual satisfactions of handling larger and more showy groups of equipment. It is not always the biggest plant which offers the greatest interest to the keen student of power economics.

The engineer working for small pay may be inclined to scoff at the idea that the mental satisfaction of dealing with old mother nature at first hand through steam, steel and electricity enhances the attractiveness of his occupation. With some disgust he may make the observation that mere ideas pay no rents or grocery bills. That is just where he is wrong. The world is looking for purposeful thoughts, pays cash for them when they are put in the right place, and only specifies that, if they are to be taken at par value, ideas shall be capable of practical application along the line of showing how something may be done better than before.

Yes, it is worth while to be an engineer, to put one's best efforts into a plant month after month, if one learns how to look beyond the immediate task and catch its larger significance in relation to the great world of applied science. Some men never catch this spirit of inquiry, never become possessed of an insatiable curiosity to find out the uttermost possibilities of their equipment and to run down and pin to earth the unusual and unexplained events which crowd thick and fast upon every keen seeker after the truth. The work as a whole must be congenial and interesting in its possibilities; if it is not so the engineer had better be selling life insurance or snipping off dress goods behind a counter, or whatever else appeals to him in a permanent way. But once let this fascination of machinery and power seize him, once let the possibilities of self-improvement through spare-hour study and the future possibilities of investigation, and invention take hold of him—then there can be but one answer to the question at the head of this page.

These are great days, and great opportunities for raising the efficiency of some detail of the world's work are at hand. For the engineer who can catch the broader outlook and make it grow by wider association with his fellows, by determined and persistent reading, by seeking after the hitherto neglected or overlooked aspects of his daily duties, by taking upon himself larger conceptions of practical life at the throttle and indicator, his occupation must inevitably be worth while, for its future only awaits unlocking by the master key of intelligent, imaginative and untiring personal industry.

A History of Technics

Elsewhere in this issue will be found an abstract of a communication to the American engineering societies from Dr. C. Matschoss, of the great German engineering society. In it he urges the coöperation of engineers in this and other countries in the preservation of records that may go to make up a fitting history of engineering achievement, or, as he terms it, a history of technics. As he points out, it is evidently because engineers have been so busy doing things that they have had no time to write about them from the historical point of view. Now the danger is that, as these men pass on, there will be lost with them the knowledge of the development of their inventions and many facts that would be of great importance to a comprehensive history of things mechanical or technical.

True, at the time, there are reports upon their work given in the form of papers to the technical societies concerned with their fields of activity, and the technical periodicals give accounts of their work, but these soon become buried in libraries of reference if not altogether lost. What is needed is the work of collating and filling in the history scattered through these thousands of volumes and private manuscripts so that there may be handed down to future generations a complete, coördinated and connected history that may truthfully show the development of the mechanical arts and industries and the evolution of their products.

A condition that is well deserving of the thought of engineers is that history has so long been considered a story dealing with wars and politics. As Dr. Matschoss points out, there are hundreds of such histories while there are none dealing with engineering advance. This is naturally the outcome of the periods when conquest was the paramount concern of nations and civilization was a march of the sword. Present-day development has undergone a radical change even from that intermediate stage when statesmanship took precedence over generalship, for now both warriors and statesmen have largely yielded place to scientists, inventors and that great class popularly known as captains of industry. They are present-day makers of history and their works the salient factor in the extension of civilization and commerce.

Now it remains for a new set of historians to come forward and write up that chapter in the world's history dealing with the events of this age of science and invention; in short, as our German brother has called it, the History of Technics. Where shall we find a Herodotus, a Livy, a Macaulay or a Bancroft who shall be to this age what the older historians were to their times?

READERS WITH SOMETHING TO SAY

Short Splice for Rope Drive

The rope drive under my charge is small, but it gets hard service. A four-strand cored manila rope, 1¼ in. in diameter, is used. The pulleys are 93 ft., center to center, and the drive runs 1600 ft. per min. on an angle of 45 deg. A sliding idler pulley with weights takes up the slack. This drive is out of doors and runs during all kinds of weather the year round. Although a good rope dressing is used, I find that stone dust, which is continually flying about, works its way into the strands and gradually cuts them. In time the core gets ground nearly to a powder, caused, I believe, by bending around the pulleys and by the strain due to the weights on the idler.

A new rope lasts about 2½ years, after that the strands begin to break until the rope is very hard to repair. A splice generally runs from four to six months before giving out, probably because the splice is a little looser than the rest of the rope, which allows stone dust to work in and, the strand, getting the most strain, gives first. A temporary fastening of the loose strand will sometimes allow the plant to continue running until a rainy day or Sunday gives the necessary time to make a permanent splice.

I use the short splice, taking 2½ ft. on each end which is unstranded after cutting off the core within 6 in. of the solid rope. One strand is unwound, the core pulled out and a short common splice is made, Fig. 1, more to hold the rope together and get the proper twist to the strands than because it is needed. Replacing the core and loosened covering, a strand from each end coming together with the proper twist, is taken and each is split in halves. Taking one-half of a strand it is wound into the other strand, leaving out a thread at each turn, 1½ in. from the other, until both are used up, cutting off all the loose ends. The operation is repeated with each strand until both ends are woven into place. With a little care one can make the pull on each strand nearly equal and in two or three days the splice will be no bigger than the balance of the rope. Fig. 2 shows the method of making a short splice.

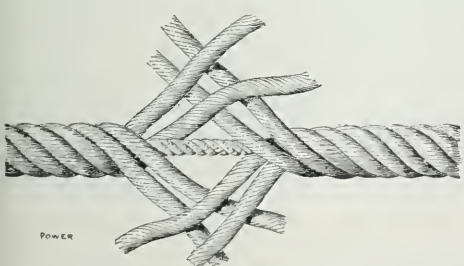


FIG. 1. CORE SPLICE

One reason I favor a short splice is that it takes very little rope, and two or three splices can be made before it is necessary to put in a new piece, which means a lot when one takes into consideration the time required to make a double splice which is required for the long splice.

I have used the long splice, but it did not last as long as the short one and takes as much time to put in. It takes on the average about two and one-half hours to make a splice with one helper. A prepared rope dressing is used which is applied as hot as can be borne on the hands. It is rubbed in carefully and, although it is a nasty job, there is the satisfaction of knowing that the rope is thoroughly covered. No trouble is had from slipping even when the rope is covered with snow and ice.

C. L. MALLERY.

Myerstown, Penn.

Taking Chances

How some engineers can take chances, and still avoid disastrous accidents, is to be marveled at, considering the way some plants are handled.

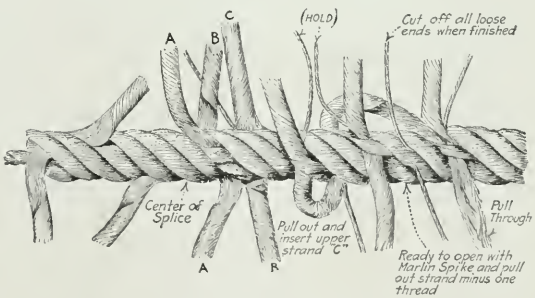


FIG. 2. SHORT SPLICE

At a plant with which I was well acquainted, the night engineer came on duty at 7 p.m. and continued on duty until 7 a.m., seven nights a week, the year round. The plant had two high-speed engines of the single valve type, with automatic flywheel governors, two return-tubular boilers, 72 in. in diameter and 16 ft. long, two duplex pumps, a system of vacuum heating, with two single-cylinder, double-acting air pumps, an electric elevator, a hydraulic elevator and an open heater. The night engineer did his own firing. The elevators were shut down for the night at 8 p.m.

Going over everything, after the heaviest of the load went off, which was about 9 p.m., the engineer adjusted the valve on the city water line to the heater. He then covered the fire heavily, shut the cylinder oil off the engine that was running, pulled out his cot-bed, and "turned in." (He shut the cylinder oil off the engine to change the position of the governor, as the springs squeaked at a certain position and kept him awake.)

A watchman, who was employed by the city, but who had nothing to do with this plant or any of the buildings connected with it, frequently came in during the evening to talk for a while. This watchman made his rounds at 11 p.m., 1 a.m. and 3 a.m. He came in and covered the fire, looked the engine and switchboard over, adjusted the voltage, if needed, saw that the vacuum and feed pumps were running all right, took a final look at the gage-glass and went out again. This state of affairs continued for a year, that I am aware of, without serious mishap.

In another plant, having a 60-in. return-tubular boiler 15 ft. long and carrying a pressure of 90 lb. gage, the engineer went home every Saturday night, leaving a banked fire. He did not come in Sunday, but started a new fire every Monday morning at six o'clock, with the water down in the water column so low he could not find it. This boiler was fed with an old injector which would not work with less than 50 or 55 lb. of steam, and not having any city water connection, he had to get 50 or 60 lb. of steam pressure on the boiler before he could put any water into it. By forcing the fire and getting the water in sight in the gage-glass, he would have about 70 lb. of steam at seven o'clock. He would then blow the whistle and start the engine. The boiler was never blown down Monday mornings, as there was never water enough in it to allow of it.

When asked why he did not come in Sunday to pull over the banked fire and put some water in the boiler, he said: "Oh, I live about 25 miles away, and I go home every Saturday and don't get back until about one o'clock Monday morning, so I take a chance on it."

JOHN C. CHESTER.

Concord Junction, Mass.

Recording Transmission Dynamometer

In the familiar type of rotary transmission dynamometer, in which a spring in torsion is used for transmitting and weighing force transmitted from a driven to a driving element, the problem has been to accurately measure the torsion angle of the spring while the instrument is in rotation. The writer has devised a simple mechanism which measures and records this angle, and with the

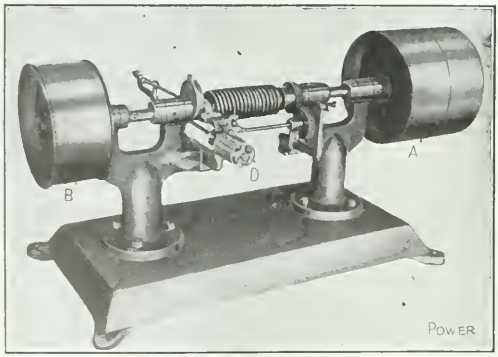


FIG. 1. RECORDING DYNAMOMETER

original model illustrated in Fig. 1 some very accurate power measurements have been made.

As may be noted in Fig. 1 the dynamometer is of that class in which the power to be measured is transmitted by a belt to a receiving pulley, *A*, on the dynamometer, and is measured as it is transmitted through the apparatus to the delivery pulley *B*.

Through gears the driving shaft rotates a drum *D* carrying an indicator card, the drum having the same angular velocity as the shaft. An eccentric mounted on the driven shaft moves a pencil back and forth across the face of the drum, giving it a simple harmonic motion, and as the shaft revolves, a sine curve is traced on the card. By allowing the driven shaft to run free this curve will

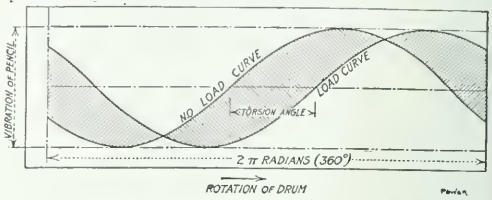


FIG. 2. DIAGRAM MADE BY RECORDING DYNAMOMETER

be traced and retraced, giving a reference line or no-load curve. Then applying the load to be measured to the delivery pulley, a second curve, out of phase with the first, will be traced as in Fig. 2.

The horizontal distance or displacement between these curves will be the torsion angle of the spring in radian measure.

Knowing the torsion constant of the spring and the revolutions per minute of the dynamometer shafts, the number of horsepower transmitted can be determined from the formula:

$$hp. = constant \times displacement\ in\ inches \times r.p.m.$$

If the load varies during one revolution of the shaft, the mean displacement must be found and applied to this formula; or better, since the area included between the curves (shown by the cross-hatching) is proportional to the work transmitted through one revolution, the number of horsepower can be computed from the formula

$$hp. = a\ constant \times area \times r.p.m.$$

The metallic pencil used to make the record is held clear of the card by a cord passing to a spring push-button by means of which it is lowered at any instant a reading is desired.

D. D. HUYETT.

Waynesboro, Penn.

Pump Suction Pipe Too Small

An experience I had some time ago goes to show how trouble can be caused by not doing work about the engine room properly.

I was called upon to locate trouble in a pump, and in looking over the outfit found that the suction pipe had been reduced from 2½ to 1½ in. The engineer informed me that the pump had been overhauled, and it certainly was in good condition. But when the trouble was pointed out to the engineer he would not believe that it had anything to do with the action of the pump.

A 2½-in. pipe, as called for by the pump connection, was run to the well from which the feed water was taken. When the pump was started it gave no trouble, and since has been giving the best of satisfaction.

J. R. HARDISTY.

Grand View, Can.

QUESTIONS BEFORE THE HOUSE

Traps and Piping of Return Systems

With interest I read Mr. Little's letter in the Jan. 14 issue, under the heading, "Points about Steam Traps." Mr. Little has laid his finger upon one of the most important features of a proper installation for piping condensation returns. It has often struck me as extraordinary that it has been the common practice of plumbers, for years, to use the 45-deg. ell and Y-connection in the drainage of buildings, whereas the steam engineer still persists in using the old square tee. Manifestly, to properly drain any system having much condensation, friction should be eliminated as much as possible, by keeping the returns flowing in the general direction of the point of discharge.

Proper arrangement of the piping will not only reduce friction but also, very materially, interference of pressures. This method of connecting returns from steam traps has been long advocated by experts on condensation, and many large trap installations have been made in this manner. If this method of piping is applied to a series of kettles and the discharges connected into a common heater, with check valves close to the "Y's," one steam trap on the series is often just as efficient as a trap on each unit of the series. Differences in outlet pressure, as high as 5 lb., are commonly found where kettles and other apparatus are working under the same initial pressure, but at different stages of the same process. Such differences will be equalized in the header and the condensation discharged, if the method of piping advocated by Mr. Little is used.

Where a return trap is used, and the system is kept closed to the atmosphere, it is practically impossible to obtain the best results without this style of piping and the use of intermittent flow traps, with positive discharge, on the apparatus to be drained. Unfortunately, what Mr. Little says is very true, namely, that it is only now beginning to be realized what a great saving can be effected with proper care in the design of the return system, by increase in the efficiency of the drainage system.

I do not agree with him in his praise of the expansion trap, which, in my experience, is difficult to operate under modern conditions of high-pressure steam, and, particularly, where there are large volumes of condensate at a temperature much above 212 deg. F. The best results, I find, are obtained by tilting traps, where the action of the traps is positive and intermittent, irrespective of the temperature of the condensate. It certainly does not pay to return to a hotwell or open heater condensate which leaves the apparatus at any temperature above 230 deg. F.

The main points to be considered are first, the rapidity of drainage, upon which depends the efficiency of the apparatus, and, secondly, the temperature at which this water is available for return to the boilers.

H. L. Peiler.

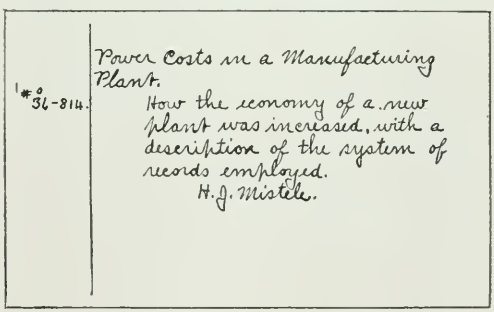
Montreal, Can.

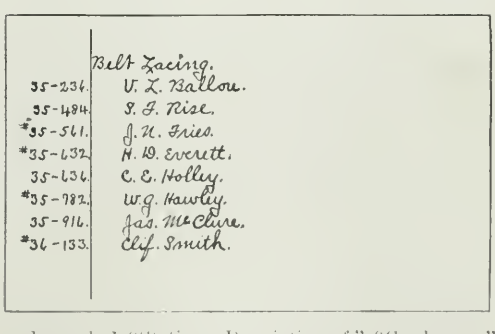
[Mr. Little did not praise the expansion trap; but remarked that, while it was a simple and sensitive form of trap to operate (to quote Mr. Little) "and gives good results, the conditions must be as near ideal as possible."—Editor.]

Card Index System

After reading the article by Mr. Thompson, in the Dec. 3 issue, under the above heading, it occurred to me that an index system I developed for myself may prove of interest.

While Mr. Thompson's system answers the purpose very nicely, the one I am keeping is somewhat more elaborate. I am using the 3x5-in. horizontal-bar card which costs $1.20 per thousand. I have the indexed card such as Mr. Thompson uses, and am cross-indexing this system; that is, if a given article such as "Power Costs in a Manufacturing Plant" be taken, I make a complete copy on five cards, placing one back of each of the indexed


Power Costs in a Manufacturing Plant.
#34-814.
How the economy of a new plant was increased, with a description of the system of records employed.
H. J. Mistele.



cards marked "Stations, Description of," "Condensers," "Records and Filing Systems," "Fuels" and "Lubricators and Lubricants." I only use one article or series of articles to a given card.

The numbers at the left of the cards give the volume and page number respectively. When the article is illustrated, I inserted a small figure (#) as shown; or when

an article is accompanied by a table which may prove useful. I insert a different figure (°), as shown on the cards.

JOHN C. SWAIN.

Indianapolis, Ind.

Ammonia for Hot Bearings

A letter in the Feb. 18 issue, from C. E. Anderson, suggested using ammonia on hot bearings. I have never actually tried it, but I know that the advantage as far as cooling is concerned would be offset by a disadvantage not considered by the writer of the letter—the destructive effect of ammonia upon copper and bronze. Therefore, if the bearing to be cooled be bronze lined it would be folly to try any such heroic remedy on it. With a babbitt-lined bearing, the same would be true, for babbitt metal contains more or less copper and so is affected by ammonia. Therefore, since ammonia applied to the bearings for cooling purposes destroys them at the same time, it is plainly evident that ammonia will not do as a cooling agent.

FREDERICK HANSA.

New York City.

[Babbitt metal ordinarily does not contain more than 1.5 per cent. copper, the composition in per cent. being: tin, 45.5; antimony, 13; lead, 40; copper, 1.5.—EDITOR.]

There is no question of the ability of ammonia to cool hot bearings, journals, etc., but I think before placing it on the outside of a hot bearing, it would be safer to cool the shaft or pin adjacent to the hot bearing. By cooling the outside of the bearing first it would have a tendency to clamp or bind on the shaft and thereby aggravate the trouble instead of alleviating it. A much better way would be to first flood the bearing with hot water, then oil the bearing and immediately after use the ammonia and water. This treatment would lessen the danger of any breaks.

GEORGE H. HANDLEY.

Newburgh, N. Y.

No doubt C. E. Anderson's method of cooling hot bearings with ammonia and water is good, but in applying it to a crankpin which has become hot enough to heat the disk, care should be taken that the pin is not cooled too quickly unless the disk is cooled at the same time, or a loose pin is likely to result. It must also be borne in mind that ammonia, even a very small per cent. of it, in the water will attack brass, and hence a bearing containing brasses might be more or less injured, though there would not be much danger of this in the few times the average bearing would receive such treatment.

G. E. MADELEY.

Brownsville, Tex.

Central Station vs. Isolated Plant

The arguments advanced by W. B. Lewis, in the Jan. 7 issue, page 33, interested me because several statements I considered at variance with modern engineering practice. He states that one 25-kw. and two 100-kw. units were proposed for an office-building plant supplying its own heat and hydraulic elevator service, the pumps being steam driven, and that the average load during the day was 20 kw. with a short peak load of 150 kw.

This is a much larger equipment than required. One 35- and one 150-kw. unit would be sufficient. It is true that the one large unit might get out of repair, and cause a temporary shutdown, but as the peak load only lasts about an hour a day it would seem advisable not to install so much reserve capacity for such short duration of load. It is everyday practice in many plants to run a lighting unit every night of the year. I have in mind generating units that are in continuous operation from Monday morning until Saturday night, 52 weeks in the year. I have charge of a 75-kw. unit that has run every night for the past 3½ years, except in July and August, when we use central-station service.

In Mr. Lewis' case, for that reason, I consider the possibility of a shutdown during the time that the large unit is required very remote. He states that the cost of the proposed equipment would have been $20,000, which is $88.88 per kw. This is far too high by at least $20 per kw. I am connected with a modern uptodate plant of 525 kw. capacity in four units with a 15-panel switchboard, and the latest improvements, and the total cost for engines, generators, foundations for engines and pumps, piping and switchboard, including main lighting and power panels was $30,800, or only $58.66 per kw.

First-class machinery for his plant ought not to cost over $60 to $65 per kw., which with the three units that he would use would cost about $14,200, and by using one 35-kw., and one 150-kw. unit, or a total of 185 kw. instead of 225, the cost ought not to be over $11,700. Assuming the first cost to be $14,200, and allowing 5 per cent. for depreciation, 5 per cent. for interest, and 2 per cent. for repairs, the fixed charges would be $1704 instead of $2400, as he figured, and the fixed charges per kilowatt-hour 3.4c. compared with his 4.8c. If the 185 kw. plant was installed the charges on the investment of $11,700 would be $1404, or 2.8c. per kw.-hr. Further on he says, "Statements that exhaust steam is a great factor in lessening the cost of power can be easily overestimated," but in reality its value is usually underestimated by the central-station representatives to make their own proposition look more favorable.

If enough exhaust is not available for heating during the day, it would at least greatly decrease the amount of live steam required, and I fail to conceive of a condition during the heating season in which no exhaust steam would be required for heating during the peak-load period, which he says occurs about 5 p.m.

The building containing our plant is of granite, four stories high, and covers 200,000 sq.ft. of area. With the outside temperature at any point below 46 deg., all of the exhaust steam is used from the average day load of about 130 kw., and a daily peak load from 3 to 7:30 p.m. of 165 kw. On special occasions we get a short peak load of about 250 kw., and even then we have one more 150-kw. unit than necessary, which increases the overhead cost of current to above what it should be.

The building mentioned by Mr. Lewis will require no more labor with a plant installed, as the boilers and pumps must be operated for the elevator service, and the only extra expense will be for coal, oil, etc., which the decreased cost of current will soon pay for, and if current was sold to the tenants at the same price that the central station charged, there would be a neat profit on the ledger at the end of the year, in favor of the isolated plant.

There is another phase of the subject that Mr. Lewis did not mention, and that is the unsatisfactory voltage of the central station which, during the light-load period when few lights are used, is above normal, but as soon as the heavy load comes on it fluctuates, and frequently drops to 90 per cent. of the normal. This is not only unsatisfactory to the tenants, but is hard on the lamps and shortens their life. Frequently there are interruptions to the service of from ten minutes to two or three hours that must be and are overlooked by the tenants, but if these interruptions occurred with the isolated-plant service it would bring down the wrath of everybody in the building on the head of the engineer, and would be advertised from Maine to Texas.

The proposition of a summer central-station service, and a winter isolated-plant service is unsatisfactory. Our institution does it every year, getting current from a large central station during July and August. The home-made current with excessive overhead charges and over $9700 per year for salaries of power-plant employees costs 2.8c. per kw. for a very satisfactory service, and the central-station current costs 2.5c. per kw. for a service that ranges from 90 to 120 volts with a normal voltage of 110, and to which must be added 2c. per kw. for overhead charges on the idle plant and labor that is kept doing a few little repair jobs around the plant that could be as well done while running, making the cost of current 4.5c. instead of 2.8c., and, furthermore, leaving the building with no fire protection except the city pressure. The power-plant men must be kept on the payroll while using central-station current or a new crew hired every year, which causes extra expense and trouble, and the best men are not going to take positions in plants that do not run steady.

There are cases in which central-station service is cheaper in the summer months, but not in the class of buildings Mr. Lewis mentions, in which hydraulic elevators are used, as steam must be carried for the pumps, even though the current is purchased. There might be some advantage if all the pumps and elevators, including the fire pump, were operated by motors.

J. C. Hawkins.

Hyattsville, Md.

Factor of Evaporation

I have just read A. A. Potter's article, in the Mar. 11 issue, on "Factor of Evaporation. His observations as to the heat in a pound of moist steam are correct, but I cannot agree with his conclusions as to the proper method of computing the equivalent evaporation from and at 212 deg.

The items in the Complete Form advised by the committee on boiler testing of the American Society of Mechanical Engineers upon this question read as follows:

57.	Total weight of water fed to boiler	lb.
58.	Equivalent water fed to boiler from and at 212 deg.	lb.
59.	Water actually evaporated, corrected for quality of steam	
60.	Factor of evaporation	lb.
61.	Equivalent water evaporated into dry steam from and at 212 deg. (Item 59 and Item 60)	lb.

A footnote referring to item 60 says, "Factor of evaporation $= \frac{H - h}{965.7}$, in which H and h are respectively the total heat in steam of the average observed pressure, and in water of the average observed temperature of the feed."

The above items and footnote are taken from Carpenter's "Experimental Engineering," sixth edition. If the Marks and Davis "Steam Tables" are used, the value for the heat of vaporization of steam at atmospheric pressure will, of course, be taken as 970.4. It will be noted that the factor of evaporation is computed for dry steam, and is multiplied by the weight of feed water actually evaporated, the moisture in the steam being first deducted. Mr. Potter states that this is inaccurate. It is true that the heat of the liquid in the unevaporated water is not included, but this should properly be regarded as lost heat, the same as radiation, heat carried off in the flue gases, and other sources of loss. Moisture in the steam, although carrying heat, is of no use for power purposes, and, in fact, every effort is made to eliminate it by means of separators, bleeders, traps, etc., before the steam is delivered to the engine. The net credit to the boiler, then, should be the amount of water actually evaporated into dry steam.

In his illustrative example, Mr. Potter has multiplied the factor based upon dry steam, 1.13, by the total water fed to the boiler, 5000 lb. This weight should have been first corrected for moisture, making the corrected weight, with his assumption of 3 per cent. moisture, 4850 lb. Also, for accurate work, the factor of evaporation should be carried out to four significant figures. The two methods of computing the equivalent evaporation per hour give the following results:

Water fed per hour, 5000 lb.
Absolute steam pressure, 150 lb. per sq.in.
Per cent. moisture in steam, 3.
Feed-water temperature, 130 deg.

1. Factor of evaporation

$$\frac{0.97 \times 863.2 + 330.2 - 97.89}{970.4} = 1.102$$

Equivalent evaporation $= 1.102 \times 5000 = 5510$ lb.

2. Factor of evaporation

$$\frac{863.2 + 330.2 - 97.89}{970.4} = 1.129$$

Water actually evaporated, corrected for quality $=$ 4850 lb.

Equivalent evaporation $= 1.129 \times 4850 = 5475$ lb.

The latter computation gives a result 35 lb. less than is given by the first method. This 35 lb. from and at 212 deg. represents the heat in the moisture in the steam, which we have rejected.

A. L. Westcott.

Columbia, Mo.

Mr. Flannery's Feed Water Heater Troubles

The Jan. 14 issue contains an interesting letter from W. A. Flannery concerning his troubles with the feed-water temperature. The letter is followed by an editorial note to the effect that the troubles are probably not so much due to improper design as to the manner of installing the heater and to the high solid content of the water.

According to Mr. Flannery's figures there is one boiler at his plant, 48 in. by 15 ft. This would be approximately 50 hp. If it is running at its rated load it is evaporating of water an hour, approximately.

$$50 \times 30 = 1500 \text{ lb.}$$

The heater is 42x100 in. and as the pump supply is 48 in. from the base and the overflow 14 in. above the pump suction, we can figure on a working water depth of say

$$48 + 10 = 58 \ in.$$

The water capacity is, therefore,

$$42 \times 100 \times 58 \ in. = 243{,}600 \ cu.in.$$

or 140 cu.ft. We thus have

$$\frac{140}{25} = 5\tfrac{1}{2} \ hr.$$

supply in the heater, only a little of which is available, however. A heater of this size is usually rated at about 2500 hp.

Regarding the loss due to radiation, the surface of the heater having water on one side and air on the other will be about

$(42 \times 2 \times 58) + (100 \times 2 \times 58) = 16{,}472 \ sq.in.$ or roughly, 115 *sq.ft.*

Consider the temperature of the water to be 190 deg. F., as Mr. Flannery says, and the temperature of the boiler room 80 deg. F. By means of Dulong's laws of radiation and convection we find that the heat loss per hour from this surface would be about 19,750 B.t.u., 140 cu.ft. of hot water would be 8400 lb. and

$$\frac{19{,}750}{8400} = 2.35 \ B.t.u.$$

loss which would cause a drop of 13 deg. in the temperature of the feed water.

Large capacity is a desirable feature in a feed-water heater, but when there is over an hour's supply, the temperature begins to be noticeably affected. The fact that the pump suction is 4 ft. above the bottom of the heater and that all this reserve water supply is not available shows poor design of this part of the heater. There is no reason why a properly designed and proportioned open feed-water heater should not give a temperature of 210 deg. F. if there is sufficient exhaust steam to heat the water.

If the water used contains 33 gr. per gal. of solids, it is no wonder the filter becomes choked up in three weeks. This is the penalty for having a bad feed water. I would venture a guess, however, that it is considerably easier to clean the filter than to clean the boiler of an equivalent amount of hard scale.

The regulation of the cold-water supply would be improved if the filter were kept clean. Plenty of hot water for the boiler-feed pump is provided in one well known apparatus on the market by having an automatic bypass which delivers unfiltered water above the filter when the latter becomes fouled so there is always a supply at the pump suction, although only a part of it is filtered. However, I understand this arrangement is patented. Mr. Flannery should not condemn all open heaters on account of his experiences with this particular one, but should see to it that the next one he gets is better adapted to the work to be done. There seems to be little help for him now except to lag the heater to cut down radiation losses, and, perhaps, remove the burlap to allow the water to pass through the filter more rapidly.

EDWARD H. ROBIE.

Philadelphia, Penn.

Mr. Flannery complains of his open heater being too large for the boiler. He is fortunate in having a large heater, the feed water used contains a large amount of solids, and this water, moving slowly through the settling chamber, deposits most of the solids in this chamber and in the filter.

Every open-heater filtering chamber should be cleaned at least every two weeks. I have found wood excelsior, tightly packed into the filtering chamber, with burlap on the top and bottom, an excellent filtering material.

If Mr. Flannery will see that the water distributer at the top of the heater is set level so that the water flows evenly to the perforated trays, also that the rod between the regulating-float chamber and the water-inlet valve is adjusted while the boiler-feed pump is in motion, he will have no fault to find with the temperature of the feed water. It is, of course, understood that the boiler-feed pump will run continuously and that the regulating valve be adjusted to maintain a constant water level—about half a glass—in the heater.

From the present action of the regulating-float chamber it seems to me that the pump suction is too small.

GEORGE MCMILLAN.

Elizabeth, N. J.

Locomotive Boiler Explosions

In the issue of Feb. 4, 1913, I read of another locomotive-boiler explosion at Detroit, Mich., on the Detroit & Toledo Shore Line R.R., on Jan. 5, which was being prepared to haul a train to Toledo. It seems that this boiler exploded under the same condition as the locomotive boiler at San Antonio, Tex., on Mar. 18, 1912.

In the examination report of these boiler explosions, no mention is made of the water being an explosive under certain conditions, the only theory seems to be that of broken stays and some other defective parts, which would naturally be found after an explosion. No mention is made of the water being out of circulation when the locomotive is at rest and no steam is released, and the amount of heat stored equally in all the molecules of the large quantity of water the boilers contain.

Now if as much heat is stored in the water, when a locomotive boiler is in full operation and under the severest condition on the road, why don't the boiler explode? Even when locomotives run into one another and are broken to pieces, no explosion occurs.

To prevent this expansive and explosive force, when a boiler is fired up for service, a part of the steam generated should be released so as to keep the water in the boiler in constant circulation, when there will be no danger to the boiler, which can be proved by demonstration.

Any one that has seen how water acts in a locomotive boiler under different conditions, will disregard the old theory on boiler explosions.

JOHN G. BROMAN.

Chicago, Ill.

The Examiners Examined

Referring to page 292 of POWER, Mar. 4, it would be interesting to have the civil-service examiners examined, to find how they would answer questions 7 and 8, and also to have them define "thermal efficiency" and "thermal per cent."

WILLIAM KENT.

Montclair, N. J.

INQUIRIES OF GENERAL INTEREST

Return Tubular vs. Locomotive Boiler—What advantage has a return-tubular boiler over a locomotive boiler?

W. C.

Return-tubular boilers of good proportions, when properly set and having good draft, are generally more efficient than locomotive boilers because of better furnace combustion and less loss of heat by radiation and by waste heat in the chimney gases.

Fluctuating Water Level—What can be the cause of the water level in the boiler gage-glass fluctuating at every stroke of the engine supplied?

P. A.

When the steam space of a boiler is small in proportion to the size of the cylinder of the engine supplied with steam by the boiler, the water level in the gage-glass may show a variation at every stroke of the engine.

Superheated Steam—What are the advantages of superheated steam?

M. L. E.

Superheated steam, being drier than saturated steam, does not condense or lose heat so readily, and, not being so quickly converted into water, its expansive force is greater than that of steam which is partly water or quickly becomes so.

Safety Valves—What is the largest size safety valve that it is advisable to use?

L. B. G.

It is not well to use safety valves larger than 5 in. because larger ones, especially pop valves, would very soon pound away their seats. Also larger valves are likely to stick and the tendency to stick might not be readily ascertained. It is difficult to get valves larger than 5 in., which will act as sensitively and perfectly as small safety valves.

Water in the Cylinder—Why is the pressure of water in the cylinder of a steam engine dangerous?

J. C. K.

If there is water in a cylinder filling the space on one side of the piston, and the water cannot escape as the piston approaches the end of the stroke, it will result in the same damage in rupturing the cylinder as though the space were filled with an incompressible solid, because water is nearly incompresshle.

Boiler Materials—What materials are the proper ones to use for the shells and heads of return-tubular boilers? What is the limit of the tensile strength for each?

O. T.

The shell, drums and butt straps are required to be of open-hearth firebox steel; the heads of openhearth flange, firebox, or extra-soft steel. The tensile strength per square inch for firebox steel is 52,000 to 62,000 lb., and for steel for the heads 45,000 to 55,000 lb.

Loose Piston Ring—If a new snap ring fitted to an engine piston is narrower than the groove so that it knocks at each reversal of the stroke, is there any way to fix it without getting a new ring?

T. A.

This defect can be corrected by taking the ring out and peening it with a hammer on the opposite sides at points that alternate in staggered relation so that the ring is made crooked laterally. This will have the effect of making the ring tight against the sides.

Governing at No Load—With the Riles governor, how can an engine be prevented from overspeeding when without load?

A. B. T.

The steam lap must be great enough to give practically no opening when the governor is in full-speed position, which means zero lead in this position. As the arm swings in, the lead increases, but not enough to give a proper lead in the usual running position unless the governor is set a little ahead. The corresponding disadvantage is an excessive lead at late cutoff, but this is appropriately compensated for best results with the average load.

Countersunk Rivets—Is it allowable to use countersunk rivets on boilers?

G. B. L.

It depends on where they are used. Countersunk rivets are rarely used on a boiler and never should be used to resist any great amount of pressure or strain. Their use is generally confined to places where there is not room for putting heads on the rivets. It is quite common to use countersunk rivets on brass or bronze flanges such as are used for blowoffs, and sometimes on small flanges which are used for steam connections.

Loss of a Governor Ball—What would happen if one of the balls fell off of a Corliss engine governor?

A. B. C.

If the friction of the governor was not too great the engine would speed up. The side twist of the single ball might cause sticking for a short time. When one of the balls is removed practically half of the centrifugal force is taken away, but the arms and connections being left, less than half of the weight is removed, and the weight would overcome the centrifugal force and the collar would drop, allowing the engine to speed up.

Pump to Fill Tank—What size pump would be necessary to fill a cylindrical tank 25 ft. in diameter and 42 ft. high in 10 min.?

J. P. C.

The tank will contain

$$25 \times 25 \times 0.7854 \times 42 = 20{,}616.75 \text{ cu.ft.}$$

This is equal to

$$20{,}616.75 \times 7.48 = 154{,}213.3 \text{ gal.}$$

To fill this tank in 10 min. would require a pump of a capacity of 15,421.33 gal. per min.

Assuming that the piston speed could be 150 ft. per min., a double-acting duplex pump with 36-in. diameter water cylinders by 48-in. stroke would do the work when operating at 18¼ r.p.m. for each stroke of each cylinder would discharge

$$\frac{36 \times 36 \times 0.7854 \times 48}{231} = 211.5 \text{ gal.}$$

and each revolution would mean four strokes or

$$4 \times 211.5 = 846 \text{ gal. per rev.}$$

or

$$846 \times 18\tfrac{1}{4} = 15{,}439.5 \text{ gal. per min.}$$

Locomotive Piston Reciprocation—Does a piston in a locomotive cylinder reciprocate on one end of the cylinder when the locomotive is in motion, or does it reciprocate on both ends?

W. R.

Reciprocation means a motion forward and backward. As motion means the change of position of a body with respect to other bodies, then, considered with respect to any other parts of the engine, such as the cylinder, the piston reciprocates. With respect to the ground, however, over which the locomotive as a whole is moving, the piston does not reciprocate, but has a continually forward motion of variable velocity. This is seen when it is considered that the piston speed relative to the cylinder is never as great as the speed of the whole locomotive, the crankpin not being as far from the center of the driving wheel as the rim. Therefore, even on the return stroke, with the piston at mid-stroke where its velocity is greatest, the piston is not moving backward as fast as the locomotive is traveling forward.

On the forward stroke the piston's velocity with respect to the cylinder is added to that of the locomotive to give the actual speed of the piston relative to the ground. On the return stroke the piston's velocity is subtracted from the locomotive's.

The piston's average speed must be the same as the locomotive's, hence on the forward stroke the piston moves faster than the cylinder and on the backward stroke the cylinder gains again on the piston. This is the basis of the argument that the piston reciprocates in the cylinder on the forward stroke and the cylinder on the piston on the return stroke. Except in respect to each other, neither reciprocates, for, with reference to the ground, both have continually forward motion.

ENGINEERS' STUDY COURSE

Mensuration—Part VIII
Cylindrical Segments and Ellipses

The steam space in a cylindrical boiler, as that between the water level $ABCD$ and the shell above, Fig. 1, is an example of the form of a *cylindrical segment*.

To find the volume of a cylindrical segment, we must first find the area of the end or base, which is a segment of a circle, and then multiply by the length of the cylindrical segment.

The same reasoning that shows that the volume of a single-base spherical segment is equal to the volume of a spherical sector minus a cone, applies to the area of a segment of a circle. Thus we see that a segment of a circle is equal to the circular sector containing it minus the triangle formed by the chord of the segment as the base and two radii of the circle as sides.

A sector of a circle being only a very great number of thin triangles with their sides adjoining, the area of a sector is equal to the length of the arc multiplied by one-half of the radius, and that of the triangle in question to one-half of the product of the chord of the segment by an altitude equal to the radius minus the height of the segment.

A formula then for the area of a circular segment is

$$A = \frac{a \times r}{2} - \frac{c \times (R - h)}{2}$$

where

a = Length of arc;
R = Radius;
c = Length of chord;
h = Height of segment.

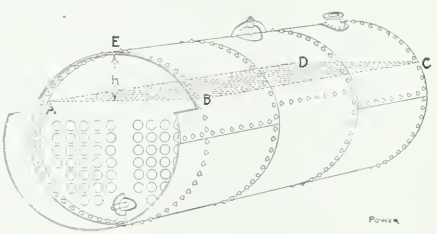


Fig. 1.

Usually the various quantities required in this formula can be measured directly so as to solve the area without any further modifications.

It must be noticed, however, that this formula applies only for segments smaller than semicircles. If larger the minus sign must be changed to plus; then the formula will apply, for the segment of a circle larger than a semicircle is equal to the corresponding sector plus the triangle.

What is known as the Massachusetts formula for the area of a segment of a circle, which is only approximate, however, requires only two dimensions, the diameter of the circle, D, and the height of the segment, h, thus

$$A = \frac{4}{3} h^2 \sqrt{\frac{D}{h}} - 0.608$$

Various handbooks give tables of segments of a circle of unit diameter, i.e., if the quantities in the table are taken as feet they apply to a circle 1 ft. in diameter or if taken in inches, to a circle 1 in. in diameter. These tables give the areas of segments from a height of 0.001, up to 0.5 (a semicircle), increasing by thousandths. (The

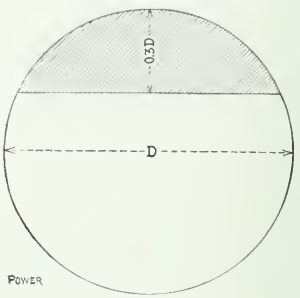


Fig. 2.

height of the segment in these tables is generally called the *versed sine*.)

Below is given such a table for segments of all heights from 0.01 to 0.5, increasing by hundredths.

TABLE I. AREAS OF CIRCULAR SEGMENTS

Ht.	Area	Ht.	Area	Ht.	Area	Ht.	Area	Ht.	Area
0.01	0.00133	0.11	0.04701	0.21	0.1199	0.31	0.20738	0.41	0.30319
0.02	0.00375	0.12	0.5338	0.22	0.12811	0.32	0.21667	0.42	0.31304
0.03	0.00687	0.13	0.06	0.23	0.13646	0.33	0.22603	0.43	0.32293
0.04	0.01054	0.14	0.6683	0.24	0.14494	0.34	0.23547	0.44	0.33284
0.05	0.01468	0.15	0.7387	0.25	0.15355	0.35	0.24498	0.45	0.34278
0.06	0.01924	0.16	0.08111	0.26	0.16226	0.36	0.25455	0.46	0.35274
0.07	0.02417	0.17	0.08854	0.27	0.17109	0.37	0.26418	0.47	0.36272
0.08	0.02943	0.18	0.09613	0.28	0.18002	0.38	0.27386	0.48	0.3727
0.09	0.03501	0.19	0.10390	0.29	0.18905	0.39	0.28359	0.49	0.3827
0.1	0.04087	0.2	0.11182	0.3	0.19817	0.4	0.29337	0.5	0.3927

If the area of a segment larger than a half circle is wanted, the area of the segment that it would be necessary to add to complete the circle can be found from the table and this subtracted from the area of a whole circle (0.7854) gives the area of the required segment.

For example, in Fig. 2, the area of the shaded segment can be found at once from the table and is 0.19817. If the area of the unshaded segment had been required it would be obtained by subtracting that of the shaded segment from 0.7854 (the area of a circle of radius 1) or

$$0.7854 - 0.19817 = 0.58723$$

If the segment area to be calculated were not that of a unit circle but of one, say, 6 ft. in diameter, it would still be proportional to the value found in the table (areas of circles are proportional to the squares of their diameters), so that it would only be necessary to multiply the value from the table by 6^2.

To find the steam space in the boiler, Fig. 1, by using the table, if the boiler is 60 in. in diameter and the seg-

ment 16 in. high, we would proceed as follows: If the diameter were 1 the segment height would be

$$h : 1 = 16 : 60$$

or

$$h = \tfrac{16}{60} = 0.2666, \textit{ call it } 0.27$$

The area of a segment of such a height, from the table, is 0.17109. Therefore, the area of our actual segment is

$$0.17109 \times 60 \times 60 = 615.924 \textit{ sq.in.}$$

and the volume,

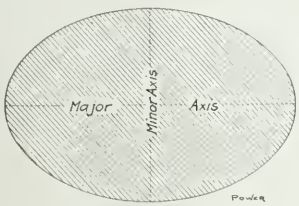


FIG. 3.

$$615.924 \times 18 \times 12 = 133{,}039.584 \textit{ cu.in.}$$

THE ELLIPSE

Fig. 3 shows an *ellipse*. The largest diameter is called the *major axis*, and the smallest diameter the *minor axis*.

The circumference or perimeter of an ellipse can be computed accurately only by the summation of a series and is such a long and involved process that it would be beyond the intended scope of this course to go into it.

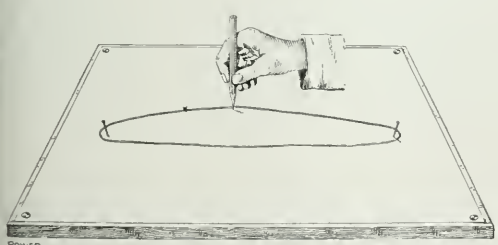


FIG. 4.

Formulas are given in numerous handbooks to figure the circumference with sufficient closeness for practical purposes.

A good approximate formula is

$$C = \pi \sqrt{\frac{D^2 + d^2}{2}}$$

where

$\pi = 3.1416$;
$D =$ Major axis;
$d =$ Minor axis.

Example: What will be the circumference of an elliptical manhole, the major axis being 15 in. and the minor axis 10 in.?

Substituting the values, we have

$$C = 3.1416 \times \sqrt{\frac{15^2 + 10^2}{2}} = 40.047 \textit{ in.} \quad \text{Ans.}$$

The only important things to remember about the ellipse are how to draw one of given dimensions and how to calculate the area.

An easy way to make an ellipse is to stick two pins in a board, as in Fig. 4, drop a piece of string, with its ends joined, over the pins and then, placing a pencil within the loop, draw it taut, as in Fig. 5. Now, if the pencil be held in this relation to the cord and be carried around the pins with its point pressing on the board, it will trace an ellipse. Where the pins are stuck are the focii (plural of focus) of the ellipse and our little experiment shows at once a truth with regard to an ellipse and its focii, namely, that the sum of the two lines drawn from any point on an ellipse to its focii, is always the same. This

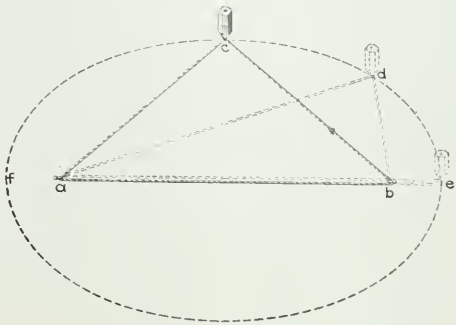


FIG. 5.

must be so because the string is unchanged in length, so that, in Fig. 4.

$$ac + cb = ad + db = ae + eb$$

Another truth then is that this constant sum of the two lines from any point is equal to the length of the major axis, for $eb = fa$. Incidentally we see that the focii are on the major axis.

Now the question is how to draw an ellipse having certain major and minor axes.

First, let us lay out our axes, as in Fig. 6, by drawing two lines at right angles of the required lengths crossing

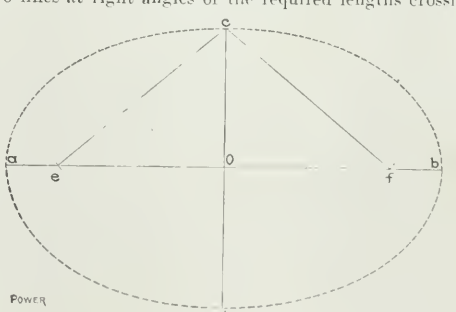


FIG. 6.

each other at their centers, as *ab* and *cd*. We know that the pins must be placed somewhere on the line *ab*, as at *e* and *f*, so that *ec* and *ef* each equal half the major axis. These points can be struck with a compass centered at *c* and set with a radius equal to *ao*. It only remains to stick another pin temporarily in *c* and tie a loop of string around *e*, *f* and *c*. Then, removing the pin at *c*, we place a pencil point within the loop and trace the ellipse.

Obviously the fatter the ellipse, i.e., the longer the minor axis with respect to the major, the closer the points

e and f will come to each other, until when they come together at o, a circle would be the figure drawn. This circle is known as an *auxiliary circle* of the first ellipse or any ellipse having a major axis equal to its diameter.

In Fig. 7 we have an ellipse and its auxiliary circle. The ellipse was drawn with its minor axis half as long as the major axis. If we draw perpendicular lines to the major axis from the circumference of the circle we will find that the ellipse crosses each one of these lines at its middle and so it would be if the minor axis were $\frac{2}{3}$ or $\frac{1}{3}$ or any other fraction of the major axis—these lines would be crossed by the ellipse at corresponding parts of their length. Incidentally this shows another way to lay out the curve of an ellipse by first drawing a circle and a number of perpendiculars to its diameter and dividing these lines in the ratio of the minor to the major axis.

But this is aside from the point we are leading to—to show the ratio of the area of an ellipse to the area of its auxiliary circle.

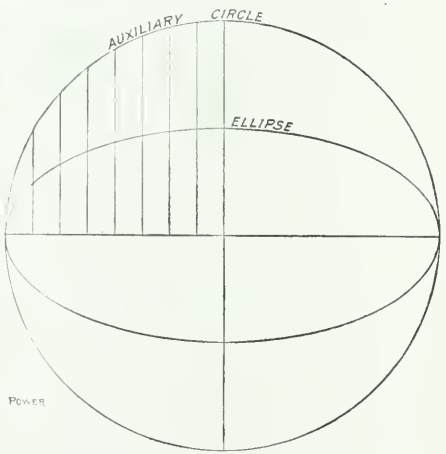


FIG. 7.

If in Fig. 1 the ellipse cuts all the vertical lines at half their height, the area of the quarter ellipse must be half the area of the quarter circle and the whole ellipse half the area of its auxiliary circle. Similarly this holds true for any other ratios of minor axis to major axis so we have the following:

Rule: *The area of an ellipse is to the area of its auxiliary circle as the minor axis is to the major axis.*

Expressed as a formula

$$\frac{A_e}{A_c} = \frac{d}{D}$$

where

A_e = Area of ellipse;
A_c = Area of circle;
d = Minor axis;
D = Major axis = Diameter of auxiliary circle.

We learned before that the area of a circle is $0.7854D^2$.

Then we can substitute this for A_c when our equation becomes

$$\frac{A_e}{0.7854\,D^2} = \frac{d}{D}$$

or

$$A_e = \frac{0.7854\,D^2 \times d}{D}$$

which, canceling the D's, reduces to

$$A_e = 0.7854\,D \times d$$

which is only another way of saying:

Rule: *The area of an ellipse is equal to 0.7854 times the product of the axes of the ellipse.*

Example: What is the area of the ellipse in the previous example?

The major axis is 15 in. and the minor axis 10 in. Applying the rule, we have

$$15 \times 10 \times 0.7854 = 117.81\ sq.in.\ \text{Ans.}$$

ANSWERS TO LAST WEEK'S PROBLEMS

1. $917.66.
2. 1229.88 gal.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Horan—Is it right to write "alright"?

Doran—No, "alright" is not right, but "all right" is right to write, all right. Much of our language is written so rotten that to write right is— Ye get me right, Horan, when I say that many of our wroters have wrotten so rotten—that is, their wrotings being written so unright—

Horan—Say, Doran, do you know what you're sputtering about?

Doran—Well, I did when I started, but—it's a hard language to speak right.

This issue of Power is dated Apr. 1, and is the thirteenth number of the new volume of 1913. A jinx? Not on that crayon portrait of your wife's dear mother! Our only hard luck is that we can't get in one issue all the good stuff that comes in weekly from our correspondents and contributors; also, that we are so dinged modest that we can't print some of the nice things our readers are saying about us.

AND IT ALMOST HAPPENED

Anybody who knows Timothy Healy, national president of the Eccentric Firemen's Association, and a member of nearly everything else, including the Cold-water Recruits and the Boy Scouts—we say, anybody who knows him says he's the divvle at a joke. The other day Tim came into the office with Jack Armour, another boy comedian, and together they put one over on Billy Spills, the engineer of this "Spillway plant." They started in to scare him out of his overalls—and it almost happened.

"Hey, Spills," said Jack, "Tim Healy is out in the library with blood in his eye. He says you wrote a pome in POWER'S 'Over the Spillway' which insinuated that he was trying to break into the Four Hundred by joining the Spugs, or Spuds, or—anyway, come out and square yourself."

Billy made the first hundred yards on one foot, but he nearly dropped when he beheld a fine figure of a man with a red—no, a brown mustache, and red in his eye.

"Young feller," says Tim, "you have traduced the fair name of an honest but hardworking man; you have sown seeds of dissension in his domestic circle, and slaughtered the peace and happiness of a faithful husband and loving father; you have— What do you mean? Answer me quick, before I say something"!— and it almost happened.

"But—but, Mr. Healy—" began the unhappy Billy.

"Butt in with no 'buts'; I've been vilified, slandered"—

"Why, Mr. Healy, it was all a joke!"

"William, I haven't slept a wink since nine o'clock this morning, when I got up, for the mental upset you have given me by your utterly unwarranted and highly inexcusable impertinence. However, for a Swede, you have turned out a fair Irish pome, and—

"Say, Jack, tell him we're only handing him some of his own medicine. It's all right, William. Jack will give you the Cremo I gave him a while ago; I don't smoke that brand myself."

And it almost happened!

Notes on Superheating

By C. R. D. Meier*

In an article by E. D. Dreyfus in the April, 1912, *Electric Journal,* the percentage of decrease in the turbine water rate due to the use of superheated steam is given as follows: 50 deg. superheat, 5 per cent.; 100 deg. superheat, 10 per cent.; 150 deg. superheat, 14 per cent. A paper entitled "Recent Developments in Steam Turbine Practice," by K. Baumann, read before the Manchester section of the Institution of Electrical Engineers, Jan. 16, 1912, gives the following figures: 0 to 100 deg. F. 1 per cent. improvement on the steam consumption for every 10 deg. F.; 100 to 200 deg. superheat 1 per cent. improvement of steam consumption for every 12 deg. F.

This paper also brings out another important point: the efficiency (referred to Rankine) increases considerably with the increase in superheat, the following figures being given: For 100 deg. superheat 2.5 per cent. better efficiency and 6.75 per cent. better efficiency for 200 deg. superheat.

The improvements in steam consumption and turbine efficiency given, due to the use of superheat, are compared to the efficiency and steam consumption with dry saturated steam. Ordinarily, however, steam supposedly dry will contain a small amount of moisture which causes a reduction in efficiency. According to the paper referred to, the efficiency will change 1 per cent. for each 1 per cent. variation in wetness, and, therefore, steam consumption measured as condensed water will be 2 per cent. higher for each 1 per cent. increase in moisture. With reciprocating engines, the presence of moisture in the steam has a still greater detrimental effect as it greatly augments cylinder condensation. For this reason an increase in economy of 12 to 20 per cent. is not uncommon with superheating only from 40 to 100 deg. F. (See "The Steam Engine," by Perry.)

The saving in coal consumption due to the use of superheated steam is not as large as the percentage saving in steam consumption; 100 deg. superheat will reduce the steam consumption of a turbine, say, 10 per cent. This means that instead of 1 lb. of water evaporated under dry and saturated conditions, only $\frac{9}{10}$ lb. of water need be required if the steam be superheated 100 deg. Assuming the feed temperature as 200 deg. the heat absorbed in the boiler for 1 lb. of steam at 150 lb. gage without superheat is 1027 B.t.u. The heat in $\frac{9}{10}$ lb. of steam under the same conditions is 924.3 B.t.u., the difference, 102.7 B.t.u., being saved. To secure this saving, 10 deg. superheat must be added to each pound of steam. According to the latest steam tables, this requires 57 B.t.u. per pound, or 51.3 B.t.u. for $\frac{9}{10}$ lb. This amount of heat, added as superheat, saves twice as much heat, 102.7 B.t.u. in the boiler.

It may, therefore, be said that by using superheated steam there is obtained a fuel economy equal to half the steam saving. This means that heat imparted to a superheater is just twice as valuable and generates just twice as much power as heat imparted to a boiler.

If by using superheated steam, 10 or 15 per cent. of the plant capacity may be generated for just half the cost of the remainder of the output, it is of great importance that the superheat for which the turbine or engines are best adapted be determined by trials and then maintained continuously. The temperature of the steam should not be allowed to fall below the mean, since economy is sacrificed, and, on the other hand, the temperature should not be allowed to exceed the predetermined mean, as troubles with valves, fittings and cast parts are likely to arise.

When the economy of superheating was first realized, superheats as high as 300 deg. were sometimes specified, and superheaters of a good many square feet of surface installed. It was found, however, that steam at these very high temperatures gave a great deal of trouble and caused rupture of cast-iron valves and fittings. By substituting high-grade cast steel, high superheats could be carried, but the added cost for these improved fittings tended to counterbalance the added returns from the use of higher steam temperatures. As a result, it has been found that the highest commercial efficiency, everything considered, is secured by the use of moderate superheat, and it has now become quite general practice to run at from 125 to 150 deg., in turbine plants, and the same or somewhat lower superheat in reciprocating-engine plants, where a low superheat eliminates losses from moisture and reduces cylinder condensation without causing lubricating troubles.

The temperature to which steam will be superheated depends upon the amount of steam flowing through the superheater tubes and its temperature, and secondly upon the amount of gas flowing over the tubes and its temperature. As the quantity of steam is controlled by the boiler load, and the temperature of the saturated steam is practically constant, the degree of superheat added will be determined by the amount and temperature of the hot gases, which will in turn depend on the design and arrangement of boiler and superheater.

There are numerous methods of installing superheaters. First may be considered that in which the superheater is placed in the path of the combustion gases after they have passed over a part of the boiler-tube surface. As the first pass in such boilers absorbs as much as 80 per cent. of the heat in the gases, their temperature when passing over the superheater surface is comparatively low, and hence the superheater surface must be quite large. It is difficult to obtain adjustment or close regulation of superheat with this arrangement. If the volume of combustion gases and their temperature varied always in exact accordance with the amount of steam generated and passing through the superheater, the degree of superheat would be practically constant. But the amount of air used to burn a pound of coal, the temperature of the fire and, therefore, the temperature of the gases after they have passed over part of the boiler surface and come in contact with the superheater surface, vary even with constant boiler load, and since the load varies with boiler pressure and the demand for steam, there are likely to be wide fluctuations in steam temperature when a superheater is installed in this manner.

*Abstracted from the "Journal" of the Engineering Society of Pennsylvania.

Forty minutes after they had been declared dead from suffocation seven out of twelve firemen recently overcome by smoke and gas during the destruction of the Westinghouse electric plant by fire in Pittsburgh, Penn., were revived by pulmotors at a hospital, and owe their lives to this life-saving invention. The Bureau of Mines has a full equipment of pulmotors for its life-saving crew, and they proved successful in many instances. "Compressed Air."

Air Supply and the Air Receiver

By Frank Richards

SYNOPSIS—A specific example in air compression, in which a compressor supplies air to an air engine. Also method of maintaining constant receiver pressure.

The following question has been brought to my notice with a request for an answer and, no doubt, the information contained will be of interest to Power readers:

"If an air compressor has a capacity of 90 cu.ft. of free air per min., and delivers it at 90 lb. gage pressure, what volume does the compressed air occupy? My position is this: I have an air engine 3½x3½ in., which is to be run by an air compressor rated to deliver 90 cu.ft. of free air per min. at 90 lb. pressure and 250 r.p.m. The engine will run at 350 r.p.m. intermittently (about 3 min. with 6 min. rest), but the air compressor will be run continuously. What size reservoir would be necessary so that the pressure would not drop too suddenly? I would like to have the calculations on this, if possible. Also, how many cubic feet of free air does it require to give 1 cu.ft. of air at 90 lb. pressure?

A. The question at the end of the above is covered by the one at the beginning, so that one answer will cover that part of it. It is generally better to call the normal atmospheric air pressure 14.5 lb. instead of 14.7 lb. as is customary, because we are generally enough above sea level to make this a better average. Then, if the air is compressed to

$$90 + 14.5 = 104.5 \text{ lb.}$$

the volume of 1 cu.ft., when compressed, will be

$$14.5 \div 104.5 = 0.1387 \text{ cu.ft.}$$

It is not necessary to consider whether the air is compressed isothermally or adiabatically, or what may be its temperature when it leaves the compressor, as it will certainly lose all its heat before being used and then the above figures will apply.

The compressor is said to be rated at 90 cu.ft. of free air per min. This is taken to be the builders' rating based upon the full piston displacement. If all the inefficiencies are to be allowed for, there must be at least 20 per cent. deducted from the theoretical capacity, which would make the actual free air capacity 72 cu.ft. and the delivery capacity would be

$$72 \times 0.1387 = 9.98 \text{ cu.ft.}$$

or, say, 10 cu.ft. per min. at 90 lb. pressure.

The air consumed by the engine at full pressure, 90 lb., and without cutoff will be

$$\frac{3.5^2 \times 0.7854 \times 3.5 \times 2 \times 350}{1728} = 13.64 \text{ cu.ft.}$$

To this 25 per cent., at least, should be added to cover clearance and other losses, making the consumption 17.05 cu.ft. per min., at 90 lb., or

$$17.05 \div 0.1387 = 122.92 \text{ cu.ft.}$$

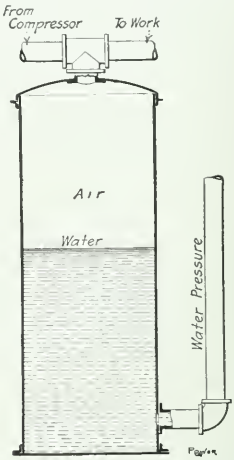
of free air per min.

As the compressor would run all the time, while the engine would run, according to the statement, only one-third of the time, the compressor delivery to supply the engine should be

$$122.92 \div 3 = 40.97 \text{ cu.ft.}$$

of free air per min. instead of 72, and it would be necessary either to slow down the compressor or to blow off some of the air at the safety valve. If the compressor were slowed down from 250 to 150 r.p.m., the free air capacity per minute would be 250:150::72:43. The 43 cu.ft. would be about right for the case as stated.

The receiver capacity would depend upon the amount of pressure drop that would be permitted, and the question does not tell this. Say that the air receiver has a



Uniform Pressure in Air Receiver

capacity of 100 cu.ft., and is filled with air at 90 lb. pressure when the engine starts. The total contents would be

$$100 \div 0.1387 = 720.9 \text{ cu.ft.}$$

of free air, say, 721. In three minutes' run of the compressor, it would put into the receiver

$$43 \times 3 = 129 \text{ cu.ft.}$$

of free air, making the total

$$721 + 129 = 850 \text{ cu.ft.}$$

In the run of three minutes, the engine would take out

$$122.9 \times 3 = 368.7 \text{ cu.ft.}$$

of free air, and

$$850 - 368.7 = 481.3 \text{ cu.ft.}$$

of free air or its equivalent at a higher pressure, remaining in the receiver. Now

$$481.3 \div 100 = 4.81 \text{ cu.ft.}$$

of free air to each cubic foot of receiver content, and 1:4.81::14.5:69.78. The pressure would be 69.78 lb. abs., or 55.28 lb. gage pressure, which would probably be a greater drop than the case would allow.

It is proper to remember that if the engine kept running at a uniform speed, taking out a constant volume of air for each revolution, the pressure drop in the receiver would not be as great as above computed on account of the gradual expansion of the air as the pressure was diminished, but it is evident that it would be enough to defeat the scheme of the installation, and a much larger receiver would be required.

The outcome of the above question is just as unsatisfactory as it always is when dealing with an air receiver

as usually installed. There is no possibility of maintaining a uniform pressure in the receiver if there is any difference in the relative rates of compression and consumption, and as far as power storage service is concerned, the receiver might as well not be.

Constant Receiver Pressure

It happens that in most places there is water under pressure which may be piped to the receiver, city water service, water pumped to a tank on the roof or otherwise provided, and this water pressure may be employed to maintain the air pressure constant in the receiver, whether there is little or much air in it, so that the entire contents may be used at the full pressure, even if the compressor is stopped, or it may be used fast or slow within the limits of air supply with perfect satisfaction.

The arrangement is about as simple as anything in the world can be. As shown in the sketch there is a vertical air receiver, and near the bottom of it an open pipe connects the interior of the receiver with the water supply, so that the water pressure is always the pressure in the receiver. At the top of the receiver is an air pipe connecting the receiver with the compressor and the air being used is taken away from the same pipe which is in connection with the receiver. No valve or contraption of any kind is required, not even a safety valve, for the pressure can never exceed the constant water pressure.

If the compressor is delivering the air just as fast as it is being used none of it will go into the receiver at all but will pass right along to its work. If the compressor is delivering more air than is being used the excess of air will go into the receiver and drive the water down in the receiver and back to its tank or reservoir. If there is more air being used than the compressor is supplying, the water pressure will drive air from the receiver into the pipes to make up the deficiency; and this it will continue to do until the air is all out and the receiver is full of water. There is not even any waste or consumption of water, as none of it is carried off or escapes. It just plays back and forth between the receiver and the water tank or reservoir, as will be evident from the sketch on the opposite page.

If there is a reliable water pressure obtainable and if it is not just the pressure desired, this can be varied by locating the receiver upstairs or downstairs, on the roof or in the cellar. Placing it 11 ft. higher will reduce the pressure 5 lb. and putting it 11 ft. lower will increase the pressure the same amount. With this arrangement so generally available, its employment should add much to the value of the air receiver in compressed-air practice. This device was employed in magnificent proportions by Bruno V. Nordberg for the reconstructed hoisting plant of the Anaconda Copper Co., located at Butte, Mont.

Coal Testing under Difficulties

By B. S. Hanson

SYNOPSIS—It was impracticable to weigh the coal or water, so a comparison of coals was made from the proximate analysis.

A short time ago the writer was called upon to make a comparative test of two different grades of coal. One grade of coal had been used for some years, and the other was a sample of coal submitted by a coal dealer. My employers desired a test accurate enough to show them the value of the sample coal in comparison with the regular coal, but objected to any extra expense in making the test.

At the plant the coal is not weighed, the car weight being accepted without question. The coal cannot be weighed in the boiler room, as it is of necessity dumped from the cart so close to the boiler fronts as to leave no room for scales or any method of measuring. The coal cannot be dumped anywhere else in the boiler room and nowhere out in the yard near enough for convenience. In fact, weighing the coal at the boilers would cause great inconvenience, and the expense of extra help. There is no scale to weigh by the cartload.

Even if the coal had been weighed this data would have been of little use without the corresponding weights of water evaporated. On looking into the matter of getting the water weight or volume, I found practically the same trouble that prevented me from getting the coal weights. The management did not wish to purchase a water meter nor to go to the expense of altering the feed piping and pumps so as to allow the water to be measured by means of barrels.

As an evaporative test was out of the question, I decided to try and make a proximate analysis of the coals. The only apparatus in the engine room was an old pan scale with a set of weights in drams. The dyer had a fine chemist's balance with a complete set of metric weights. It was inconvenient to use the dyer's balance, but by borrowing a spare set of his weights, I was able to test and correct my scale.

The coals were sampled from the cartloads as they came into the boiler room by taking shovelfuls from all parts of the load, mixing and quartering them down on a large iron plate, breaking the lumps while mixing and finally putting a 2-lb. sample in a tin can with a close-fitting cover. As many as eight samples were taken from each coal. Each of the 2-lb. samples was divided into two parts, one of which was weighed on an accurate scale and put over the boilers to dry out; the other half was put through a coffee grinder and ground as fine as possible. This part was also weighed and dried, and then both samples were weighed again and from the loss in weight the percentage of moisture was calculated. The two samples agreed very closely, the fine-ground sample showing slightly less moisture than the other, which was accounted for by the drying out in grinding.

To obtain the volatile contents a sample of the fine-ground coal, of about 3 grams weight was placed in a retort made of a 1¼x3-in. wrought-iron nipple with a cap screwed on each end and a small hole drilled in one end to permit the escape of the gases. This retort was then heated to a red heat in the flame of a gasoline blowtorch, which was concentrated around the retort by means of a muffle made of asbestos millboard and firebricks. The retort was kept hot for 15 min. after the last trace of gas

had shown at the escape vent. It was then allowed to cool, the coke content was removed and carefully weighed, and the difference between the weights of the coal and coke was taken as the weight of the volatile gases in the sample.

The coke was then crushed and returned to the retort and one of the caps was left off. The retort was heated red again and the coke was gradually burnt to ash, which generally took about two hours. After the ash was cooled off it was weighed, and the difference between the weights of the coke and the ash was taken as the weight of the fixed carbon. The different percentages were then calculated from these weights. In this way I was able to do three analyses a day and complete 24 analyses in a week and a half.

Samples were taken from the coal in the storage piles, which had been in storage six months, from the coal being used as it came in from the cars, and from the two sample cars of the new coal to be tested.

After the analyses were made the results for each coal were averaged and the heat units per pound calculated by means of the following formula:

$$Q = (Per\ cent.\ fixed\ carbon \times 146.5) + (Per\ cent.\ volatile \times constant\ K)$$

For the coal in use K was taken as 180 and for the new coal as 200, K varying according to the percentage of volatile present. Great accuracy is not claimed for this method, but as both coals received the same treatment the results were accurate enough for comparison. At the same time the behavior of the coals in actual use was carefully watched and the amount and character of ash noticed. The behavior of the coals was about what would be expected from the analysis.

The results of the analysis are given in the accompanying table. Coal *A* was the regular coal taken from the cars, *B* was the same kind of coal taken from the storage pile and *C* was the new coal. Coal *A* and *B* is a Cumberland deep vein run-of-mine and was then known as boat coal. Coal *C* was reputed to be from the George's Creek district and was all rail coal. All rail coal is not broken up so much as the boat coal, being handled less. Coal *A* and *B* cost $4.45 per gross ton delivered in the boiler room, while coal *C* cost $4.30 delivered.

PROXIMATE ANALYSIS OF COALS

Coals	A	B	Average of A and B	C
Fixed carbon	66 950	67 757	67 350	67 375
Volatile	22 430	19 648	21 040	15 525
Total combustible	89 380	87 405	88 390	82 900
Moisture	3 050	3 000	3 030	2 650
Ashes	7 570	9 595	8 580	14 450
B.t.u. per lb.	13,845	13,463	13, 654	12,957

Coal *A* and *B* is a high-grade Eastern free-burning bituminous coal. It smokes a little and the ashes clinker some but not badly. The coal makes steam well with either natural or forced draft.

Coal *C* is a fair grade of semibituminous, which smokes very little. The ash content is high, but the coal does not clinker. This coal contains no more fixed carbon than the regular coal and contains 5.49 per cent. less combustible. In comparison with *A* and *B* coal *C* stands as follows in each particular.

	Per Cent.
Fixed carbon	100 04
Combustible	93 79
Volatile	73 79
Moisture	87 46
Ash	168 42
B.t.u.	95 00

In comparing the cost of the coals add to *A* and *B* 3¼c. per ton and to *C* 5½c. per ton for ash removal. Then, for the same heat value as given by a ton of *A* and *B* costing $4.4825, there will be needed 1.053 tons of *C* costing $4.5858, or 10½c. more than *A* and *B*. With a coal consumption of 4500 tons per year, the increased cost of using coal *C* would be $464.85.

The practical test showed that the steam-raising capacity would not be as good with coal *C* as with *A* and *B*, as *C* did not burn freely, needed more draft and made dirtier fires. To burn coal *C* to advantage and maintain sufficient steam at all times, it would have been necessary to use forced draft at times and to install shaking grates so as to facilitate the removal of dirt from the fire. The increased amount of ashes shown by the analysis of coal *C* was confirmed by the practical burning test, here the increase in the amount of ashes was so large that the yardman complained about the extra work of removing them.

After receiving the report the manager decided to stick to the old coal. He brought out the specifications given by the dealer who sold coal *A* and *B* and it checked with the analysis very closely. The firm guaranteed: fixed carbon, 66 to 68 per cent.; volatile, 22 to 24 per cent.; sulphur, not over 2 per cent.; moisture, 2 to 4 per cent.; ash, 5 to 7 per cent.; B.t.u., not less than 13,500.

System in Charging

By W. H. Booth

SYNOPSIS—A satire on a system of charging for electric current, showing its ridiculous features, by applying the principles in the conduct of a country store.

Many men have worked all their lives in one place. Such a one was Joe Smith, who left our village straight from school and started as junior clerk at the big electric-light works in Blackborough about ten miles distant. He would come home occasionally at week ends and holidays and we had then the opportunity of observing the phases through which he passed by way of high-up and low-down types of collars, turned up trousers, hats of various brims and fancy vests.

His father kept the little general store at the High St. corner and managed to pay his way, but did not amass much of a fortune. Joe sometimes came with him to the inn on Saturday evenings and was wont to air his ideas on what he called matters of commerce. He felt sure that his father was not in the right path financially, but he could not say where the old man was in the wrong, for he had never taken any interest in the store. But he was sure he could make plenty of money by a proper system of charging such as he had learned at the big works at Blackborough. He bragged that the lighting station had made 5000 pounds deficit last year and it must be a paying concern if it could pile up all that.

Joe was not very lucid in his explanations, but we understood him to say that every consumer paid four pence a unit as a beginning if he kept one lamp or any number of lamps alight 24 hr. every day in the year; but if he lighted fewer lamps he paid more for the time the fewer lamps were lit, and if he had an evening party once a quarter, and did not invite the station engineer or the secretary, he paid double for all the current used that quarter. But if he invited the engineer this man would bring a key that would put back the electric meter every

other day not being the fourth day of each alternate week after the party. And he told us of other rules and exceptions and of the army of clerks calculating the fines on the poor widows who did not use enough electricity, and making up the big discounts for the rich men who had parties every night.

The whole business was explained by Joe to be a sort of cross betwixt the system of maximum demand and minimum light and the undulating flat rate constant low-voltage system, and if his father would condescend to learn from him he would put his store books in order and start him on a sound system.

So the old man went off for a holiday and Joe, who was taking a summer vacation, started in to run the store for a week. Joe spent all Sunday looking into the customers' names and books, and was ready for action on Monday, letting down the shutters at 8 a.m.

Old Granny was his first customer: item, a penny bloater—charge, two pence instead of the old price of one penny. Joe explained that Granny only bought two bloaters a week at a high rate of maximum daily demand. Then he sold 60 bloaters for a half penny each to a fellow who had been watching the game and who promptly distributed them at ¾ pence each to a crowd outside whom he called a "syndic." Joe made the curate pay a fine of six pence on his groceries, and explained to him that if he would come in and buy one shilling's worth every day instead of six shillings' worth a week he could have a bonus of two pence a day and so save 18 pence a week by his more level demand.

Mrs. Brown, who had bought a loaf of bread about twice a week, was charged six pence in place of four pence a loaf. The vicar, who was accustomed to buy three or four cases of mineral water at one time, had 35¼ per cent. added to the price, but was told he should call twice a day for a bottle at a time and would then be given a discount of 11⅔ per cent. The vicar had been senior wrangler* at Cambridge and these fine figures were Joe's concession to a brother mathematician.

This sort of thing went on for a week, but whatever else it did, it did not increase output. Joe would come around to the pub after closing time and discuss the question of the strain made by the heavy demand for whole cases of stuff and of the small profit made on one penny bloaters. Sam Jones tried to show him it did not really cost him much to sell bloaters, for people went into the shop and put down a penny and just lifted the fish and said, "Morning" and cleared off. This sort of thing he said went on all day and a crate of the blessed things had gone by night, yet there were never more than two buyers of bloaters in the shop at one time and it was the one-at-a-time buyers who got rid of the crateful and not the three families who bought each six fish a week.

Joe positively refused to sell a hundredweight of potatoes to the manager of the brush factory, who had a big family and bought things in fairly large quantities. "It didn't matter," said Joe. "So much the worse for a man if he bought a ton at a time, for his demand factor was low and his maximum demand was cruelly high." The big families in the town, before the week end, were sending their children every half hour for an egg or half an ounce of salt and a dozen beans and Joe was run off his legs keeping pace with the demand.

During the first two days his receipts had increased 50 per cent., but during the last four days, when people had learned the value of a steady purchase rate, the output of goods went up considerably, the receipts fell to about three-fourths and the profits to zero. Joe had achieved the deficit of which he was so proud in the case of a big station at Blackborough. The old man was very patient about it. He told Joe that he liked the little customers, "They mounts up in the course of a day and I learns things from them, and they keeps me alive."

The chairman of Joe's company lives in our village, or in a big house just outside, and he had seen all that had gone on in the week of Joe's experiment. It is reported that he has decided to change the system of charging at the Blackborough works. He had not thought of the matter before, being only a director and the chairman, but now he had really looked into the matter and could not think how such a rotten system of charges had been brought about. He was heard to say it was up to the electricians to sell stuff at fair rates to all and that it was time they learned the effect of diversity of demand, for they had simply choked off the best part of the demand and sold below cost to the survivors.

*The highest honor man in a mathematics examination.

Preservation of Technical History Urged

Last fall, Dr. C. Matschoss, on behalf of the Verein deutscher Ingenieure, visited this country to study our technical progress in connection with his historical researches. Since his return to Germany he has addressed a communication to the American engineering societies, acknowledging his gratitude to the various societies, institutions and individuals who were of service to him in his quest for information, and urging that the societies interest themselves in collecting material for the history of American technics and industry.

After outlining his own work during the past fifteen years and the work of others in Germany and elsewhere abroad in compiling such histories as the development of the iron industry, the steam engine, the locomotive, the electrical industries, etc., Dr. Matschoss continues with the following plea for the work:

We need the history of technics in the same way as we need the history of any other human work. If we understand the great influence of all engineering work on the development of our culture and civilization—and nobody can now deny this influence, in the United States, least of all—it follows that we cannot longer neglect the history of this evolution. It is not possible to write the history of mankind and leave out the works of the engineers. Why have we no history of technics but hundreds of histories of wars, politics, etc.? The history of technics can be written only by engineers or by the help of engineers. During the last century the engineers have spent their whole time in making history and no one has had time to write it down; now it must be changed. Among the thousands and thousands of engineers we should find one or two willing to work in the historical line. And it is time to do that, for every year we lose prominent pioneers, and too often we forget with them that which they have done for mankind.

We need the history of technics also as a source of enthusiasm and idealism for our younger generation. Nothing that is great in the world is done without idealism. History shows us in the characters of the great inventors and pioneers some of the greatest idealists who have ever lived. We must tell the lives and deeds of these men to our young students. We should not forget that behind all our machines and other great engineering works made of inanimate material stand living men. The prominent engineers of today know that often it is more difficult to handle men than machines. Therefore we must learn to understand the work

of the men in the technics. Also in social interests such a history would have great value in our days.

We need the history of technics because no really educated man can be content to know a few facts only, he wishes to know the evolution. Many outside the engineering profession admire technical industry and are astonished at certain results, but they do not like technics because they know nothing of the growth of all these works, they cannot see the men who stand behind all the iron and steel. Therefore I believe that a really great history of technics is also the best means of increasing the reputation of the engineering profession.

Many ways will be possible to help forward these historical researches. It is not my task to suggest what you may do in this direction, but I trust that in America, so justly celebrated for its energy and initiative, a way will be found if there is a will.

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For Engineering Experiment Station in Ohio

The Ohio Society of Mechanical, Electrical and Steam Engineers, in view of the unquestionable advantage to the industrial and manufacturing interests of Ohio of a state engineering experiment station, recently passed the following resolutions:

Whereas, the manufacturing, industrial and engineering interests of the state of Ohio are taxed, but are not aided and fostered by any scientific and technical department of the state government, and,

Whereas, these interests form a large part of the wealth-producing and tax-paying resources of the state, and,

Whereas, many of the states of the union foster these interests by the establishment and maintenance of an engineering experiment station, therefore,

Be it resolved, by the Ohio Society of Mechanical, Electrical and Steam Engineers in session at its twenty-sixth semi-annual meeting, in the city of Akron, that this society commends the idea of the establishment of an engineering experiment station at the Ohio State University for the benefit of the people of the state engaged in the manufacturing, mineral, transportation and other industries of the state; and that we call upon the General Assembly to approve and support all reasonable efforts looking to the establishment of such an engineering experiment station; and further resolved that the members of this society as citizens urge upon the General Assembly and its individual representatives and senators the great desirability of passing a bill for the creation of the station and of appropriating adequate funds for its support.

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Forty-Fifth Anniversary of the Albany Lubricating Co.

Forty-five years ago, in 1868, the firm of Adam Cook's Sons was founded in Albany, N. Y., as the Albany Lubricating Compound & Cup Co. Its founder, Adam Cook, was a man of energy and perseverance, and the company was the direct result of conditions at that time, when oil was the only practical substance used for lubrication and as suitable means for applying it were not generally understood, it was costly and inefficient. The main drawback was that a large percentage of the oil would drip away before it had accomplished its object of reducing friction. While many engineers of that time devoted their energy to the perfection of some suitable method of applying oil to bearings, Adam Cook determined to try and make some change of the lubricant itself. He spent many days in testing out innumerable combinations of mineral and animal oils and grease until he finally produced a compound which he called "Albany Lubricating Compound." The engineers soon called it "Albany Grease" and it has ever since been known by that name.

The Albany plant was outgrown in four years and in 1872 larger quarters were secured in New York City, at 231 West St., New York City. In 1881 it was found necessary to move to still larger quarters at 313 West St. Additions were continually made to meet the growing demands for its product, but it was finally decided to concentrate the different departments and plan the manufacturing system according to modern principles and to bring under one roof all of the various departments of the business. After 30 years the West St. plant was abandoned and the present modern commodious plant at 708-710 Washington St. was placed in service.

This modern fireproof plant is a monument to Adam Cook, a man who saw a need and had the courage and perseverance to work until he had the correct solution, but more important as a reminder of the man who perfected the modern lubricating compound, is the millions of grease-filled cups in the mills and factories of the land, in the mines and on the railroads and automobiles, and finally in the air.

NEW PUBLICATIONS

STEAM TURBINES, Their Theory and Construction. By H. Wilda. Translated from the German by Chas. Salter. Scott, Greenwood & Son, London, 1912. Pages, 191; 4½x7 in.; cloth; illustrated. Price, $1.25.

The literature of the steam turbine grows apace (at least as measured by the number of volumes devoted to it). There has been enough development to furnish material for many books, each individual in its matter or method, or both. Each author must think that he has new material to present, or at least new ideas as to the manner of its presentation, but if one were to sift them for one comprehensive work he would find much that had been duplicated.

The author of the book under review spares us any prefatory excuse or explanation as to how he happened to do it. He does, however, furnish a table of the nomenclature adopted throughout the book, a practice decidedly to be commended.

The book is divided into five chapters, the first of which treats of entropy, the flow of steam, critical velocity, and classification of turbines according to the arrangement of the vanes. The second chapter deals somewhat mathematically with the flow of steam through the steam turbine. Chapter III takes up the details of steam turbines, Chapter IV their general arrangement, Chapter V condensers, and the utilization of exhaust steam, and Chapter VI, practical applications of steam turbines

ENGINEER'S HANDBOOK ON PATENTS. By William Macomber, Lecturer on the Law of Patents in the Cornell University College of Law. Published by Little, Brown & Co., Boston. Flexible leather; 270 pages 4½x7 in.; 6 illustrations; table of contents and index to sections. Price $2.50.

This is a handbook addressed to engineers, inventors and manufacturers, not so much as a treatise on the patent law as a convenient handbook of special value to those interested in deciding the essentials of a good patent and property rights in patents. The work attempts to cover the subject by giving practical answers to the questions of what a patent is, what invention consists of, what is patentable and what constitutes novelty; and to shed light upon the problems of obtaining a good patent, of knowing what a patent covers, patent litigation and property rights in patents.

Legal phraseology and terminology have been omitted as far as practicable and the style of the author is calculated to be both clear and acceptable to the average layman. A study of the book should enable the user to avoid lines of thought which have resulted in failures on the part of other inventors and enable him to secure the full benefits of a successful invention, the explanation of what is patentable being clearly detailed.

The problem of property rights is clearly set forth in the closing chapter, and, as information to inventors and engineers, is well treated by the author, who truthfully says that " it is a subject which concerns the engineer vitally and perhaps more frequently than any other in the patent law."

Statements in the text are fortified by quotations from the court decisions referred to and good indexing and paragraphing render the subjects of the work readily accessible.

FOUNDATIONS AND MACHINERY FIXING. By Francis H. Davis. D. Van Nostrand & Co., New York. Semiflexible cloth; 146 pages; illustrated; 4x6½ in. Price, $1.

This little work is at least unique in affording a separate treatise on a subject which has been strangely neglected as a specialty in engineering publications. Except for occasional articles in the technical press, there is practically no literature on the subject. The importance of good foundations for engines and machinery is so widely recognized that the author's efforts should not fail of appreciation.

The work will be found especially valuable to that class of practical engineers who are only occasionally required to decide upon provisions for engine foundations, and although the author's treatment of his subject may be disappointing to those who may seek entertainment in theoretical speculations, the latter class of readers may be awakened to prac-

tical methods of meeting problems that baffle mathematical computation.

The subject is divided into ten chapters and is treated under the heads of functions of foundations, nature of soils, designs of foundations for engines, turbines and electric generators, the materials and construction of foundations, holding-down bolts, causes and effects of vibration and methods of insulation.

The reader is furnished with 15 tables of data pertaining to the bearing power of soils, the proportions and weights of foundations successfully employed for various types of steam, gas and oil engines, dimensions of anchor bolts and plates, etc.

Although written by an English author, the work is remarkably free from terms and expressions unfamiliar to American engineers, is written in a clear style, printed in a readable type, and is well illustrated.

THE THEORY AND PRACTICE OF MECHANICS. By S. E. Slocum, professor of applied mathematics, University of Cincinnati. Published by Henry Holt & Co., New York, 1913. Pages, 442; illustrated; cloth. Price, $3.

This is intended primarily as a textbook for students in engineering colleges, and is well suited for that purpose, the theoretical principles developed being applied to the solution of practical engineering problems. It should also prove useful as a reference book for designers.

The text is divided into eight parts: Tables of mathematical and physical constants, kinematics, fundamental dynamical principles, statics, friction and lubrication, kinetics of particles, kinetics of rigid bodies and dynamics of rotation.

Under the subject of kinematics the difference between linear and angular velocity should have been pointed out, and this illustrated by application to problems on kinematic linkages. Also the kinematics of rolling cylinders and cones, parallel and straight line motions should have been included under the applications of kinematics.

Work, power, fundamental and derived units are clearly defined, and the treatment of simple structures is illustrated by well selected practical problems.

The subject of friction is especially well treated. Tables are given for the average values of the coefficient of friction for various substances and for mechanical efficiencies of various machine elements and prime movers. The average efficiencies given for electric motors and generators appears somewhat high. The part dealing with roller and ball bearings is very complete and practical, being illustrated by calculations of the size of bearings for passenger cars in railway service. Under friction transmission, paper and iron friction wheels are described and compared with toothed iron gearing.

The chapter dealing with the kinetics of particles and of rigid bodies are extremely theoretical, and most of this could well be omitted in a course on mechanics given to engineering students. The sections dealing with moment of inertia should have included solutions for sections usually used in engineering practice, as a book on practical mechanics should form the basis for the study of the strength of materials

Derivations of governor and flywheel formulas are given in a very simple and practical manner, The calculation of the weight of a flywheel for an engine capacity in kilowatts is inaccurate, the author converting indicated horsepower into kilowatts hy multiplying by 0.746 without taking into consideration mechanical and electrical losses. The dynamics of the engine is well presented and the balancing of reciprocating stationary engines and locomotives is given in detail. Gyroscopic action is also considered at some length, and its application is illustrated by the monorail car and automobile torpedo.

In general, the whole subject matter of the book, and especially the part dealing with dynamics of rotation, is presented clearer and in a more definite and practical manner than in most books on the subject.

DESIGN AND CONSTRUCTION OF STEAM TURBINES. By Harold Medway Martin, Longmans, Green & Co., New York, 272 pages; 7½x10¾ in.; illustrated; cloth. Price $8.50.

This work is founded largely upon and consists in large part of articles hy the same author which have had the advantage of previous presentation and discussion in the columns of "Engineering." The first chapter defines concisely the impulse and reaction types by comparison with Pelton and Girard waterwheels. Chapter II deals with guide blades and nozzles and Chapter III with their efficiency. This takes care of the steam element not only of the stator, but of the rotor of the reaction machine, leaving only impulse buckets to be treated, and these form the subject of Chapter V. The correction for departure from adiabatic expansion, i.e., the effect of nozzle and blade efficiency upon volume and velocity is then considered.

For the purpose of reducing actual performances to other conditions of pressure, superheat and vacuum correction curves are used. Superheat corrections are practically identical for every type of turbine and over a wide range are nearly independent of the initial pressure. The gain by superheating is much greater than that theoretically due from the increased temperature of the steam. The gain from increased vacuum, however, is almost invariably less than that theoretically due, and the vacuum correction is not the same for all turbines. The effect of increased initial pressure can be reduced to a vacuum correction. If the initial and final pressures are increased in the same ratio, the efficiency of the turbine is almost unaltered. Seven correction diagrams for superheat, pressure and vacuum are given.

The succeeding nine chapters are devoted to turbine design, and Chapter XVI to the thermodynamic principles involved. The author then takes up such details as balancing; dummy and gland packings; high-speed bearings; the strength of rotary disks; and geared turbines; and steps a little aside from his subject to devote a chapter to the condenser. Illustrated descriptions are then given of the De Laval turbine; velocity compounded turbines; the compound impulse turbine; the Parsons type; disk and drum turbines, and the Ljungström turbine. This portion is accompanied by a large number of plates illustrating the various turbines in detail, and it is evidently these folding plates which have necessitated the rather more than ordinary size of volume. The book is excellently printed in large type and contains much of interest, even to the man who cannot follow the mathematical treatment of the more involved chapters.

OBITUARY

Frank P. Ohmer, chief engineer for the Indiana & Michigan Electric Co., South Bend, Ind., dropped dead from heart failure, Mar. 3, while inspecting some of the machinery at the power plant. Mr. Ohmer was well known throughout the Middle West.

PERSONALS

Sanford H. Smith, formerly of the Allied Publishing Co., has become associated with the "Isolated Plant Magazine," New York City, in the capacity of managing editor.

A. M. Houser, mechanical expert for the Crane Co., Chicago, Ill., although busy in connection with the Bridgeport, Conn., branch of the company, found time to visit this office a few days ago.

G. G. Ross, of Ross & Taggert, consulting engineers, 114 Liberty St., New York City, has returned to the home office after a year's absence. Mr. Ross has been reorganizing a large manufacturing plant.

W. A. Ostrom, chief electrician in the Saskatoon (Sask.) power house for the past year, has resigned to enter again the employ of the Canadian General Electric Co. as superintendent of construction in the West.

C. R. Smith, designer of stations for the General Electric Co., who has been in charge of the reconstruction work of the Newport News & Old Point Railway & Electric Co., at Hampton, Va., has returned, having completed the rebuilding of the station and ice-making plant.

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An amusing instance of undue prejudice in regard to the goods of different manufacturers was recently quoted in connection with the working of the recent act for the suppression of illicit commissions. A certain engineer-in-charge praised some lubricating oil supplied by A and condemned the oil supplied by a competing firm B. The plant owner, suspecting the existence of some outside influence, secretly changed over the contents of the oildrums submitted by the different firms and asked the engineer to give both oils a further trial. In ignorance of the substitution, the engineer continued to give unqualified approval to the contents of A's drum, and similar condemnation to the oil in B's drum. We do not know what happened to the engineer, but he no doubt learned a very useful lesson. There is, of course, a moral for the employer, and that is, the more poorly paid a servant is, the more susceptible he is likely to be to financial inducements to betray his trust. In theory this argument should not apply, but human nature is a very difficult thing to bring closely into line with theory.—"The Power User."

Bituminous Coal Sizes

Relative to bituminous coal sizes the Bureau of Mines informs us as follows:

Bituminous coals are not prepared by systematic sizes. In all of the bituminous coal fields a great deal of coal is shipped as "run-of-mine." In the coal fields of Pennsylvania, Ohio and West Virginia, a considerable part of the coal is merely screened through bars about 1½ in. apart. In the Middle West the coal is usually screened over shaking screens with round holes. The coal passing through a 6- or 8-in. diameter hole and over a 3- or 4-in. hole is called small or railroad lump; the coal through a screen with 3-in. diameter holes and over 1½-in. or 2-in. holes may be called "egg" coal; between 2½ and 1-in. may be termed "nut" coal; between 1- and ½-in. may be termed "pea" coal and below that, "slack or duff." There are no precise grades and there are all kinds of mixtures, so that in buying it is always customary for the buyer to specify that the coal shall be passed over and through certain size screens; bar screens or shaking screens as the case may be.

There is a little better uniformity in washed coal of the West, but even these vary from the so called standard sizes which range from "nut" to "duff" but are always specified as washed coal.

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Washington's Great Undeveloped Water Power

The Cascade Range of Washington and Oregon has an inexhaustible store of running water. In the opinion of the hydrographic engineers of the United States Geological Survey few areas in the United States present more favorable opportunities for the development of water power.

The crest of the range is 6000 to 8000 ft. above sea level, and the higher peaks extend into the region of everlasting snow. From Mount Rainier in Washington to Mount Shasta just south of the Oregon-California line, both more than 14,000 ft. in elevation, many snow-covered peaks are the perpetual fountains that supply the flow of strong rivers running westward to the coast. The precipitation of the area is heavy, the Cascade Range receiving about 100 in. of rainfall a year.

The streams of the Cascades possess in high degree the requisite characteristics for the successful development of water power, namely, steep gradient, abundant water, and comparatively uniform flow. Add to these the enormous resources of timber, metal and other minerals, and lands as yet developed only in small part but promising an extensive future market for water power, and it becomes apparent that the large areas of country surrounding the Cascade Plateau have in the undeveloped power of their streams very great potential wealth.

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Electrification of London's Suburban Railways

The London, Brighton & South Coast Ry., which since 1909 has electrified some 70 miles of its suburban lines, recently decided upon a further electrification, to include, when completed, at least 170 miles of additional trackage, says a consular report. The work will extend over four years. The lines to be transformed will be divided into sections.

The whole of the company's suburban system, in the area extending from London to Croydon, Purley and Coulsdon, and from London to Sutton and Cheam, is to be electrified. This action has been decided upon in view of the satisfactory results of the company's electric service now in operation. This road alone of the railways of London which have adopted electrification is committed to the single-phase, overhead, alternating-current system, and will employ it in its extension. Two of the principal reasons for continuing the system are that it is not desirable to have a third rail and that it will be necessary, in the near future, to extend the electrification to Brighton and Eastbourne.

The company purchases its current from the London Electric Supply Corporation. In consequence of the increased demand, the latter company will be compelled to add materially to its present plant, thus making it one of the largest in England.

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Glibly as everyone now talks of horsepower there are few things concerning which the average man knows so very little as he does of what strength the human or the animal is capable of exerting.

Some idea of this has come to light through a series of interesting tests recently made to determine the respective pulling power of horses, men and elephants. Two horses weighing 1600 lb. each, together pulled 3750 lb. or 550 lb. more than their combined weight. One elephant weighing 12,000 lb. pulled 8750 lb. or 3250 lb. less than its weight. Fifty men, aggregating 7500 lb. in weight, pulled 8750 lb., or just as much as the single elephant; but, like the horses, they pulled more than their own weight. One hundred men pulled 12,000 pounds.

NEW EQUIPMENT

ATLANTIC COAST STATES

The installation of a water-works system at East Long Meadow, Mass., is under consideration. F. C. Burton is chairman of the board of selectmen.

Plans are being prepared for the construction of a power plant at Clayville, N. Y., to be erected for H. D. Wood, of Phoenix, N. Y.

The installation of new equipment in the municipal electric-light plant at Jamestown, N. Y., has been recommended by C. O. Johnson, superintendent of the plant.

The power plant of the Jamesburg Light & Power Co., Jamesburg, N. J., was destroyed by fire recently. The plant will be rebuilt at once. Estimated loss, $10,000. Frederick Greenslade is superintendent.

SOUTHERN STATES

Stanley Scott is interested in the project to install an electric-light plant at Eastville, Va.

An election has been called for Apr. 15 at which the citizens of Wilson, N. C., will vote on the proposition to issue $80,000 in bonds for the improvement of the municipal electric-light plant.

Plans are being prepared by J. Newton Johnson, Florence, S. C., for the construction of a water-works system at Manning, S. C.

The citizens of Abbeyville, Ga., will hold an election on Apr. 8 to vote on the proposition to issue bonds for $8000, for the construction of a municipal electric-light plant.

Plans are being prepared by the J. B. McCrary Co., Atlanta, Ga., for the installation of an electric-light plant and water-works system at Marshallville, Ga. Estimated cost, $20,000. J. O. Boonton is mayor.

An election will probably soon be called to vote on a bond issue for the installation of an electric-light plant and water-works system at Lake Butler, Fla.

Bids are being received by the authorities of Micanopy, Fla., for equipment for the electric-light plant, including a 75-kw., 2300-volt, 60-cycle, three-phase generator, with switchboard, instruments, exciter, noncondensing, four-valve steam engine, 100-hp. boiler with piping, feed-water pump; engine to be directly connected to generator.

CENTRAL STATES

An expenditure of $16,000 is planned by the Thornapple Gas & Electric Co., for the improvements of its power plant at Hastings, Mich. Lewis W. Heath, Hastings, is manager.

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POWER

Vol. 37 NEW YORK, APRIL 8, 1913 No. 14

GRATITUDE

By BERTON BRALEY

They sent me out in the wilderness to build 'em
a power plant
Where there wasn't a rail in thirty miles and the
trails were rough and scant;
They sent me out with a trapper's map and a
husky, healthy gang
That lived and worked from day to day and let
all else go hang;
There wasn't a sign of a wagon road and the
trail was a rocky track,
And we had to take machines apart in pieces a
mule could pack,
So, slow and careful we hiked along—and gee,
what a weary tramp!
Till we reached the place I had planned the dam
and there we made our camp.

The sad coyotes howled
Like some uncanny choir,
And bear and wildcat prowled
Beyond our dying fire,
But we—in slumber deep
We lay the whole night through,
For men must get their sleep
When they have work to do.

The ice came down with the winter, the floods
came down with the spring,
And we fought with that raging river as you fight
with a living thing,
And we heckled the fat directors back there in
the busy town
For they kept trying to stir us up while keeping
expenses down;
Whatever supplies we needed, of lumber,
cement or steel,
I had to beg and pray for in many a wild
appeal,
And while we were bucking nature in tempest
and cold and heat
The fat directors wired me, "Why isn't the job
complete?"

They'd fume and fuss and fret
And scold and interfere,
While we—we simply sweat,
And tried to keep our cheer.
In spite of doubt, delay
And fat directors, too,
We went right on our way
For we had work to do!

They sent me out in the wilderness to build 'em a
power plant
And it's running now as it ought to be, though
some folks said "It can't."
And now that everything's smooth and fine
they've fastened a can to me
And they've put in a brand-new graduate with a
nice fresh school degree.
But say, it was fun while the job was on—a re-
gular man's-size game!—
For we built the dam and power plant in spite
of the bumps that came.
So the boy is welcome to have the job and sit
in the office chair—
There's a power plant in the wilderness—and I
—I put it there!

So if a job you've got
Away "t'ell an' gone,"
Some far and lonesome spot—
I wish you'd take me on;
I'll ship to Borneo
Or China, or Peru,
I don't care where I go
If I've got work to do

Gas Engine and Steam Turbine Power Plants

By W. C. Turner

SYNOPSIS—Hydraulic pumps are used to supply water to nozzles for washing down phosphate pebble rock. A representative power plant consisting of three gas producers and three gas engines, directly connected to electric generators. There are also two water-tube boilers and a 1000-kw. steam turbine.

Due to the development of the phosphate mining industry in Florida, the combined power-plant equipment makes quite a showing of uptodate machinery. About seventeen companies at present are engaged in mining in the pebble rock district by hydraulic means. The strata of phosphate, from 3 to 10 ft. thick, lies under from 3 to 25 ft. of surface ground, or overburden, as it is termed. The latter consists mainly of sand, which is also removed by hydraulic methods. Fig. 1 shows a mine with the overburden removed, also the pit pump and hydraulic guns.

Fig. 1. Phosphate Mine with Overburden Removed, Showing Pit Pump and Hydraulic Guns

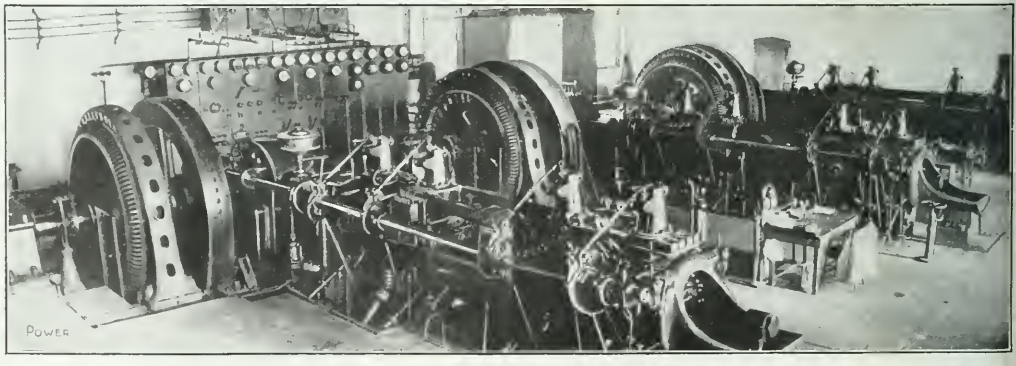


Fig. 2. Gas-Engine Installation at a Phosphate Mine

Hydraulic guns, pivoted in a spherical socket are used to "cut" the bank. They have 2½- to 3-in. smooth-bore nozzles and are supplied with water at a pressure of 125 lb. These nozzles may be swung in any plane through a great range, and permit of starting at the surface and working down, washing the overburden into sumps from which it is removed by direct-connected, motor-driven volute pumps. The phosphate rock is similarly mined, and is pumped to a preliminary washing apparatus.

Until a few years ago the rock was mined by steam-driven units, supplied by conveniently located boilers, the steam lines, however, often being run for a distance of 800 or 900 ft., sometimes over damp ground, and necessarily, on account of periodical changes having to be made in location, were not covered or maintained in the best mechanical condition. The boiler-furnace fuel was wood, of which there was an abundance, but which was finally secured only at great expense, due to the increased distance of hauling and railroad maintenance expense.

Pumps

Pumping stations furnishing water for the guns were located as near the mines as possible, where an abundance of water could be secured. They represented the most

economical means of handling the water and have always been kept up to a high degree of efficiency. Some of these stations contain duplicate triple-expansion pumping units having 15, 24 and 40 by 24-in. cylinders, and surface condensers, the cooling surfaces of which are included in the pump suction lines. A vacuum of 26 in. is maintained. Boilers in each station, of the return-tubular type, supply steam at 125-lb. pressure. These have recently been equipped with oil burners.

Changing from isolated steam-driven to centralized electrical equipment was accomplished at one plant with but slight interruption to the mining operations. A producer-gas power plant was installed in 1909 and was the first step toward centralizing the system.

Gas Equipment

The plant consists of three double-acting, two-cylinder, four-cycle, 18x24-in. gas engines, Fig. 2, running at 200 r.p.m. The engines are supplied with gas by three updraft gas producers, burning bituminous coal. The air blast during operation is furnished by motor-driven fans. Saturated water vapor is generated by waste heat, a

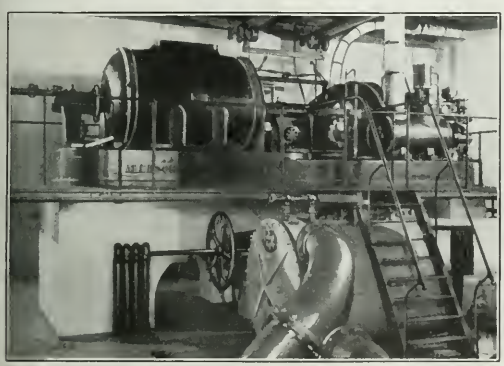


Fig. 3. Steam Turbine and Auxiliaries

vaporizer superimposed on the producers absorbing heat from the gas as it goes to the scrubbers. By means of a regulating device which operates from the blast pressure, and thermometers inserted in the blast pipes convenient for observation, a comparatively close relation of the volume of steam to the air supplied may be maintained at the producer. The gas is cleaned by wet scrubbers and further by centrifugal tar extractors. A 5000-cu.ft. gas holder keeps a constant pressure of $\frac{3}{16}$ in. of water on the engine-supply-gas mains.

All electric generators, directly connected to the engines, are of 200 kw. capacity and deliver 60-cycle current at 2300 volts, which is stepped up to 6600 volts in transformers, located in an adjoining room. At the mines it is stepped down to 550 volts for use in the pump pits, at portable transformer stations, which include switch panels equipped with automatic circuit-breakers, for controlling the various pit motors. The mines are at distances of two and five miles respectively from the power plant.

The power house is near a small lake from which water for all generating purposes is pumped by direct-driven centrifugal pumps; the pump house is near the lake. Recent observations of the gas-plant operation covering a period of 72 hours represent results obtained under the best operating conditions:

Total kilowatt hours at circuit panels	28,990
Total kilowatt hours in generator leads	35,097
(Power metered in the generator leads includes that consumed by station auxiliaries, tar extractors, etc.)	
Per cent. power delivered to circuits of that indicated in generator leads	82 6
Average load factor on generating units, per cent	81 2
Coal consumed, lb.	64,014
Pounds of coal consumed per kw.-hr. delivered from generator	1 824
Average thermal value of gas, B.t.u.	125
Thermal value of coal, B.t.u.	14,500

Circulating-water observations taken at one engine while the engine maintained a load of 225 kw. indicated a circulation per engine, including pistons, of 692.3 lb. of water, which was raised from a temperature of 60 deg. to 88.6 deg. F., hence a heat transfer of 19,799.78 B.t.u. per min., or 59,399 B.t.u. per min. for the three engines, the recovery of part of which was given consideration in the layout of the turbine station.

Steam Plant

Recently, due to increased mining operations, more generating equipment was required and a 100-kw. steam turbine, Fig. 3, was installed. There were also two water-tube boilers of 435 hp., each equipped with superheaters designed to superheat steam of 175-lb. pressure, 125 deg. F. The boilers, Fig. 4, are equipped with oil burners, but the furnaces may be readily converted into coal burners.

Exhaust steam is delivered from the turbine to a surface condenser having a steam-driven dry-vacuum pump, and an electrically driven centrifugal hotwell pump which returns the condensate to an elevated tank, thus maintaining a suitable pressure for a gravity circulation of the return water through heaters in the gas-engine exhausts. A vacuum of 28 in. is maintained with circulating water of 85 deg.

This plant has been in successful operation for some

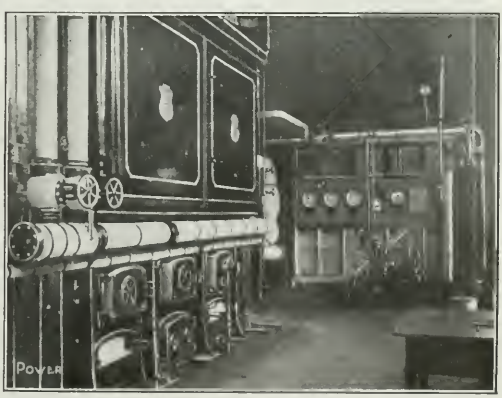


Fig. 4. Boiler Room

months, at about 70 per cent. of its rated capacity. The gas plant is held in readiness for increased mining development.

A complete set of recording instruments is included in the equipment. A turbine inlet pressure gage, in full view of the fireman, indicates the plant-load conditions, and facilitates instant control of the gas burners in response to demands for steam. Permanent sampling apparatus for flue gas has been installed, the CO_2 apparatus

being arranged so that flue-gas analyses may readily be made, or an Orsat may be inserted for a complete analysis.

Provision has been made by tapping into the hotwell return from the condenser for closely checking, by weight or volume, the water rate of the turbine, during regular runs and without inconvenience. A 500-gal. underwriter fire pump connected directly to the boilers is installed, and piped to fire hydrants and taps in the yard and the building interior.

A storage battery of 56 cells, five positive plates per cell, furnishes power for lights and excitation upon starting up. The potential coils of the controlling device are energized from the exciter busbars, and hold open the switch of an auxiliary lighting circuit connected directly on the battery. In the event of an interruption to the main units at night, sufficient light is automatically switched on to enable the operators to handle the apparatus with dispatch and without danger.

Circulating water from the small lake is returned to the extreme end opposite the pump intake, and in flowing from the condenser discharge to the lake on its return passes through several hundred feet of semi-tropical vegetation which absorbs considerable of the initial heat of the water as it leaves the condenser, the drop in temperature before entering the lake is 4 deg.

All circulating pumps and exciter units are electrically driven by synchronous motors, as is also a single-stage, direct-connected air compressor; the latter operates a deep-well air lift. This type of motors was selected on account of its desirable tendency to correct the lagging power factor resulting from the induction motor loads on the feeders. The motor fields are excited from the station-exciter buses. Ammeters indicate the field and armature current.

In view of utilizing the exhaust from the gas engines for heating the feed water, none of the auxiliaries except those of the boilers and the dry-vacuum pump are steam driven. Simplicity is thus secured and there is eliminated the greater possibility of fouling the feed water with oil from their exhausts. An open feed-water heater is used, containing an oil separator which will take care of the exhaust of any steam-driven units which may be installed in the future.

Both plants are so arranged as to be operated by a single crew. On several occasions the gas-engine units have been in parallel with the turbine, and the electrical regulation promises to be all that can be desired.

Slippage of Reciprocating Pumps

By Mervin K. Baer

SYNOPSIS—It is folly to assume a general figure of 5 per cent. as the slippage of reciprocating pumps. As shown by the test results in this article the slip may be anything from 5 to 85 per cent., depending on the condition of the pump, the discharge pressure and piston speed.

There is little reliable data obtainable on the slippage of reciprocating pumps; either the indifference on the part of the operating engineer has been the cause of the scarcity of experiments along this line, or else has resulted from this lack of authentic information. In either event, the subject has been passed by with a few statements and figures which are misleading to say the least.

A brief outline of the nature of slip is necessary for the purpose at hand. It may be divided into three losses:

1. Loss due to leakage past the valves, both suction and discharge.
2. Loss due to leakage past the piston or plunger.
3. Loss due to entrained air and to air pockets.

The first is the most important, and is due to the necessarily late seating of the valves, to the wearing of the valves and their springs, and to their improper seating. The second loss is due to the wearing of the piston or plunger, and is liable to be much greater with inside-packed plungers than with those of the outside-packed type. The loss due to entrained air is caused by an exceptionally low suction pressure; that due to air pockets may be charged up to faulty construction. Neither of the last two losses are ever found in a well designed pump.

It is easily seen that the effect of slip is twofold. It reduces the amount of water which can be pumped, and increases the power for a given quantity of water. It is a common occurrence to see the statement that the slip of a certain size pump is, say, 5 per cent. On the strength of such an assertion engineers have used this value promiscuously without considering that there are a great many conditions which tend to change it.

Two factors which enter prominently into the question of slip are piston speed and discharge pressure. Fig. 1 shows how these factors affect the slip of any pump. The region of minimum slip is at the normal rated speed of the pump. The higher the pressure at this point, the higher will be the slip. No matter how high the pressure may be, the slip of the pump is less at this rated speed than at any other speed, the pressure being the same. Going along the curve in either direction, it may be noticed that the slip increases. With a decrease in piston speed, there is a rapid increase in the slip; with an increase in speed, there is likewise an increase in slip, although in this direction it is more gradual. From the standpoint of slippage, it would appear that it is much better to run a pump at a speed higher than normal rather than lower. The fact that the slip increases with the pressure will undoubtedly have been surmised.

Figures were omitted from the curves as no set of values could be given which would cover the entire field of pumps. Each pump will have its own set of curves, depending upon its construction and condition. However, no matter what these may be, the curves will follow the general shape of those shown in Fig. 1. Although no concrete values can be given which will cover the general case, the following instances will give a good idea of the range of values one might expect to find in various pumps:

A 16 and 9 by 12-in. duplex fire pump, whose valves

were in good working order, and whose piston clearances were approximately 0.02 in. for each plunger, was thoroughly tested for slippage. The results are shown in Fig. 2. At 150-lb. pressure the slip was 16 per cent. when the piston speed was about 140 ft. per min., while at 25 ft. per min. the slip jumped up to about 83 per cent. At 10-lb. pressure and 25 ft. per min. piston speed the slip was 31 per cent.; at 140 ft. per min. it was only 5 per cent. These curves give some idea of the immense variations there are in pump slippage.

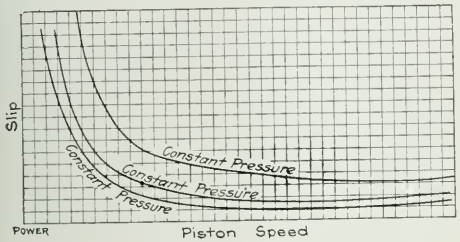


Fig. 1. Variation of Slip with Piston Speed and Discharge Pressure

Tests on the pumps of the Chicago water-works showed the following values of slip, under normal operating conditions:

	Slip, per cent.
68th Street station	11.7
Lake View Station	11.8
West Side Station	20.7
22nd Street Station	28.5

A test of pump No. 7 of the Milwaukee water-works, made in June, 1911, showed a slip of 43 per cent.; after repairs were made to the valves, this value was reduced to 9 per cent. These pumps were all large and to see if such large values of slippage existed in smaller pumps, a 24-hr. test was made on a 7½ and 4½ by 6-in. duplex

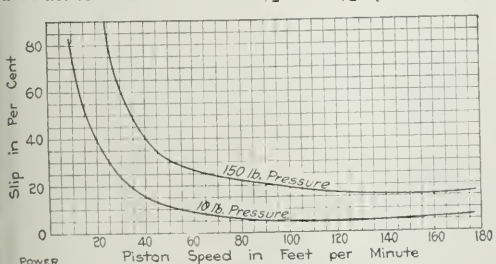


Fig. 2. Results of Test on Duplex Fire Pump

boiler-feed pump running under normal operating conditions at about 75 lb. pressure and 6 r.p.m. The slip was 58 per cent.

If a pump is not kept in good order the slip may increase rapidly, even if the running conditions are kept constant. The following data are available concerning slippage tests on a 10-million-gal pump:

	Slip, per cent.
June 10	1.7
June 26	5.2
Aug. 8	7.8
Aug. 15	12.1
Sept. 15	20.0
Sept. 18	22.9
Oct. 14	28.5

A careful perusal of the cases just cited, or of a thorough test made on any pump, will show the fallacy of the assumptions that up to the present time have been considered good practice. Engineers are beginning to understand that they cannot assume the slip of their pump to be, say, 5 per cent. They are beginning to realize that there is a wide range of values of slip, and that for the economical operation of their plant they must determine how they can reduce this value to a minimum.

New Riley Underfeed Stoker

The main features of the Riley underfeed stoker are that the coal is forced into slightly inclined retorts by a plunger with which each retort is fitted, the fuel feeding by gravity to the plungers from the hopper about them. The number of retorts and plungers depends upon the width of the stoker.

Moving fuel-bearing grates, placed at an angle of 20 deg., form the upper side of the fuel retorts. They are really narrow grates with side tuyeres for the passage of air from the air space below the grates to the green fuel, below the line of combustion. This feature is shown in Figs. 1 and 2. The grates are baffled, and, although air

Fig. 1. Sectional View through Stoker

passes freely through them, ashes or fuel do not sift into the air chamber below. Beyond the underfeed retorts are sets of overfeed grates extending the width of the retorts, Fig. 2.

The overfeed grates reciprocate in unison with the underfeed fuel-bearing grates and also with the plunger, receiving motion from extensions of the plunger wristpins. Each fuel-carrying grate is supported at its upper end by a rod parallel with the coal ram. In the ends of these rods are bolts passing through holes in the plunger pins. By this arrangement, although the plungers make full travel, the movement transmitted to the reciprocating grate is less, due to the lost motion made possible by the distance between the heads of the bolts and the ends of the rods. This lost motion is adjusted by distance blocks to suit the character of the fuel. That is, the plungers make a partial stroke each way before the movement is transmitted to the fuel-bearing grates. This feature is shown in Fig. 3.

At the lower end of the overfeed grates are pusher noses which force the refuse slowly but continuously toward the

rear bridge-wall of the furnace as they move back and forth over a part of the ash-supporting plates. The lower end of the carrying side bars, slide back and forth on a plate at the rear of the stoker just in front of the apron, Fig. 1.

An idea of the ash apron construction can be obtained from Fig. 1. The overlapping plates are supported by racks engaging pinions on a shaft extending to the outside of the furnace setting. The plates of the apron hang down over the end of the racks which can be moved backward or forward by hand and the ash-discharge opening adjusted to suit the amount of refuse from the fuel discharged over the end of the apron into the ashpit. This opening is left just large enough to pass the refuse and

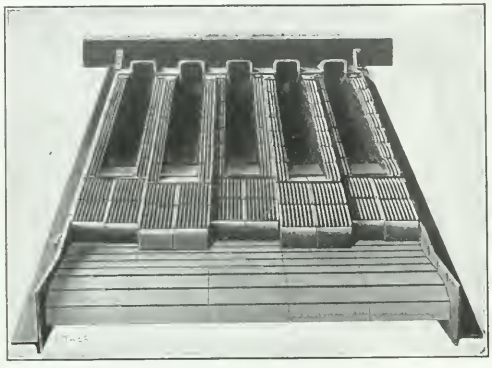


FIG. 2. SHOWING RELATIVE POSITION OF MOVING PARTS

yet maintain an effective air seal between the ashpit and the furnace.

Two I-beams carrying the supporting plates and self-dumping adjustment constitute one assembly unit; three heavy angles, carrying the cylinders and crankshaft, constitute another assembly unit. Each of these units is separately installed and the moving retort parts are dropped into place. The retort bottoms are fixed at their upper ends and their furnace ends slide on the reciprocating overfeed grate extensions.

Precaution against possible damage by obstacles blocking the movement of the plungers is had by using a hardened-steel ring with a pin passing through it and the connecting-rod. The ring bears against the end of the forked sleeve mounted on the wristpin, so that the thrust on the

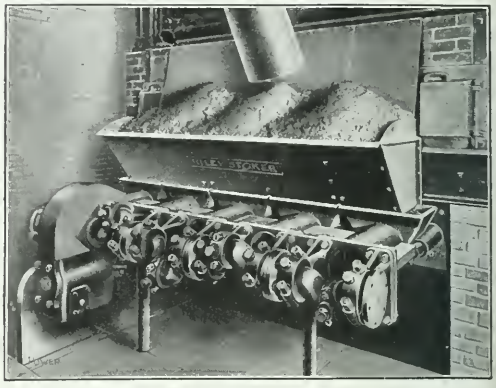


FIG. 4. FRONT VIEW OF THE RILEY STOKER

plunger tends to shear the pin. If the pin shears because of an obstruction in front of the plunger, the connecting-rod slides idly through the sleeve between the ends of the wristpin without carrying the plunger with it. The pin is easily renewed while the stoker is in operation. This safety device is equally effective for all positions of the crankpin.

Connection between the blower and the stoker is by a chain and sprocket wheel, one of which is shown in Fig. 1. The other sprocket delivers power to the gear mechanism which drives the plungers. The stoker and fan work in unison. As the sprocket wheels are placed on the shaft and not removable by the attendant, the ratio of air to the coal fed to the grates is fixed. This adjustment is determined by the flue-gas analysis and so long as the same grade of coal is used the sprocket wheel should not be changed.

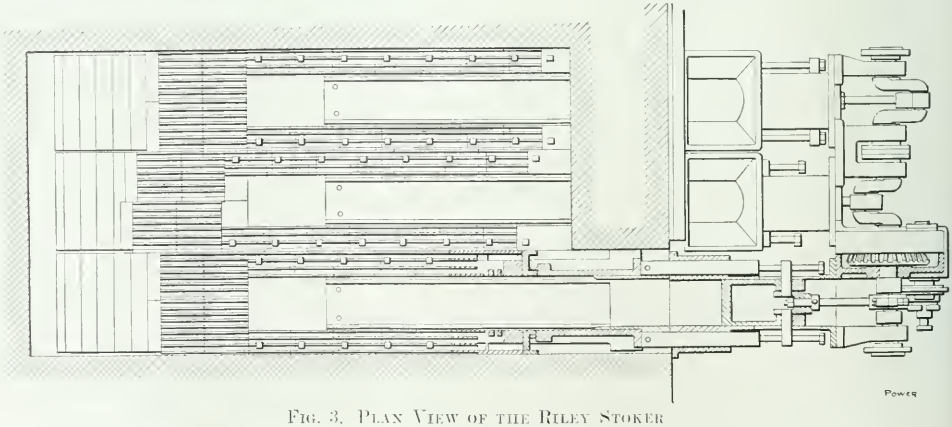


FIG. 3. PLAN VIEW OF THE RILEY STOKER

Referring to Fig. 1, the course of the fuel is easily followed. Dropping from the stoker hopper it is forced into the retorts by the plungers operated by the crankshaft on

the front of the furnace setting, Fig. 4. When the retorts become filled the fuel is carried by the fuel-bearing grates which form the side of the retorts. As these grates are operated in unison with the retort plungers and as each plunger is driven by a crank set at a different angle from the one beside it, the fuel-bearing grates between any two retorts are given a shearing motion in relation with each other, while moving in opposite directions. This motion prevents clinkers forming above the air openings.

The reciprocating motion of the fuel-bearing grates gradually forces the coking and burning fuel toward the rear end of the furnace. Air is supplied to the fuel through the side tuyere openings as indicated by the arrows, Fig. 1. The reciprocating motion of the fuel-bearing grates, the overfeed grates and the pusher noses, all working in unison, forces the refuse toward the bridgewall over onto the ash-supporting plates and into the ashpit. Reverberating effect of the hot gases against the grates is impossible because clinkers must break along the line of movement of the grates, and thus give the hot gases free exit to the boiler tubes.

The driving mechanism of the stoker is visible from the outside and accessible. The air space beneath the stoker is reached through a door or through the opening in the front air plate or the side door. Removing the front air plates gives free access to the under part of the stoker for repairs, etc. The stoker requires a small amount of head room, which permits of ample combustion-chamber space. Fig. 1 shows the short air duct between the fan blower and the air space below the stoker. This feature eliminates losses due to the friction of air through long air ducts and the necessary power to maintain the excess air pressure to overcome this loss. Hence, less work is required of the blower fan in maintaining the proper air pressure in the air chamber below the grates.

As the overfeed grates extend entirely across the stoker beyond the underfeed retorts, all of the partially burned fuel comes in intimate contact with air. The air is of less pressure than the underfeed air, and, therefore, is not destructive to the lighter fuel bed on the overfeed grates.

At low ratings this air pressure may be little or nothing, being regulated by the fireman by operating the damper shown in Fig. 1, between the air space and the overfeed reciprocating grate. Therefore, the air is always under the control of the operator, who can burn the combustible in the coal just as completely as he wants to, whether at high or low ratings.

This stoker is manufactured by the Sanford Riley Stoker Co., Worcester, Mass.

The Bi-centennial of the Steam Engine

By Erick H. Low

SYNOPSIS—In 1712, twenty-four years before James Watt was born, and over sixty years before he and Boulton began to build engines at Soho, the first reciprocating piston engine was put to work. The bicentenary of this epoch-making event has passed without adequate notice.

Ask a hundred people who invented the steam engine and ninety of them will tell you James Watt, yet he was only one of several inventors who brought the steam engine to a condition of practical and useful application.

The first piston steam engine was erected 200 years ago last year; but the idea of using heat and steam as sources of power is older than the Christian Era.

The first recorded use of heat as a source of power was 200 years B. C., at which time Hero was interested in the subject and we are indebted to his records, as well as to his inventions. His first record tells of a temple door which was opened and closed by heating air. This was probably used to work upon the superstitions of the people for the doors were open as long as a good fire burned on the altar. Fig. 1 shows a working drawing of this engine. The fire on the altar heats the air inside, which expands, exerting a pressure on the water in tank *A*, forcing it through the siphon *B*, into the open bucket *C*, which is hung by a rope which passes over a pulley, and thence to two pillars about which it is wound. *D* is a counterweight which acts on the pillars in the opposite direction from *C*. The pillars are fastened to the edges of the door and as they rotate the doors open or close. As the water fills the bucket, it overbalances the weight *D* and opens the door. When the fire goes out, the air cools and the water runs back through the siphon and the weight pulls the door to.

The next engine, a mere toy, was invented by Hero

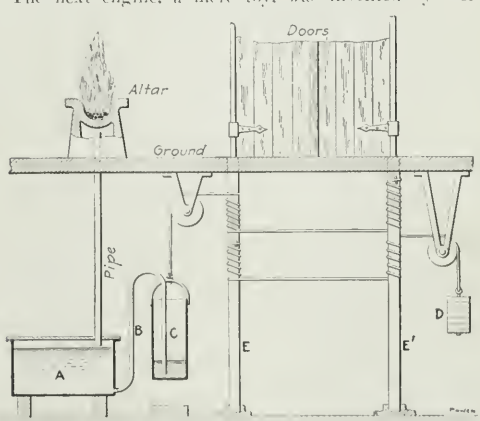


Fig. 1. An Ancient Use of Heat for Power. How the Temple Doors Were Opened by the Altar Fire

himself, and is shown in Fig. 2. It consisted of a boiler *A* and hollow sphere *B* hung in trunnions connected to the pipes *CC'* from the boiler. The sphere had two outlets, *EE*, turned tangent to the sphere and at right angles to the first axis. The steam from the boiler filled the sphere and escaped through the outlets *EE* where the reaction caused the sphere to rotate.

After this there were a number of toys, such as a wheel with a number of buckets, which was blown around by a jet of steam, and different forms of siphon engines. Without doubt, steam was the mysterious agent which performed many of the mediæval miracles; yet the first recorded use of any importance was in 1543. Blasco de Garay, a Spanish naval officer, is said to have built a boat which was run by paddles driven by steam. The king was much pleased with it and promoted him to some high office; but nothing further was heard of his invention and its secret probably died with him.

The Marquis of Worcester writes about an engine, but the records are incomplete and given more to what the engine could do than to how it worked. One of these engines was set up on the Thames about 1653. It raised water more than forty feet.

We now come to the age of rapid development of the steam engine and the first invention is that of Thomas Savery. Toward the end of the 17th century, the mines of England had reached such a depth that water came in too fast to be handled by the old method, and a cry was raised for some new way to keep them dry. In one mine, they employed 600 horses at immense cost. Savery

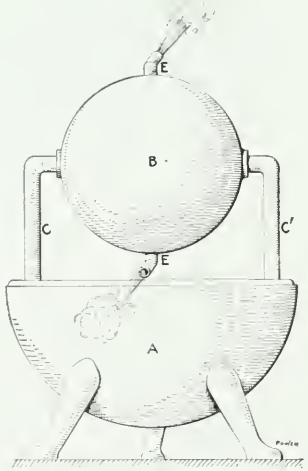


Fig. 2. Hero's Engine. The First Steam Turbine

invented a form of steam pump, with which he hoped to overcome the difficulty.

A boiler *A*, Fig. 3, delivered steam through the pipe *B* to the cylinder *C*. When all the air in *C* had been displaced by steam, the valve in *B* was closed and the valve in *F* opened, permitting a stream from a reservoir *G* to be played into the cylinder. The water causing the steam to condense formed a partial vacuum, which was filled by water forced up by the air pressure through *D*. When the flow into the cylinder ceased, steam was again let into *C*, forcing the water up through *E*.

This engine, which was patented in 1698, met with little success because of the great pressure necessary to force the water to any considerable height in *E*.

At this time, Newcomen and Cawley, the one an ironmonger, the other a plumber, invented an engine on the theory of Papin (1690), who said that heating water in a cylinder would cause a piston to move out, when if the cylinder were cooled, the pressure of the air would push it in again. Newcomen and Cawley used this idea but made the steam outside. Fig. 4 shows the working parts of this engine. A boiler *A* furnishes steam for the cylinder *B*, which has a piston hung by a rod and chain from a beam *I*, the other end of which is attached, by means of a chain and rod, to the piston of a suction pump *C*. When the chamber *B* is filled with steam, the piston *E* is at the top. When water from *D* is sprayed into it, the steam condenses causing a partial vacuum

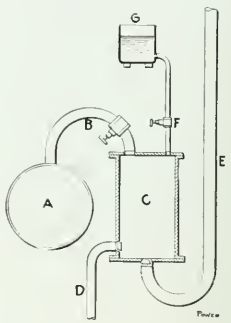


Fig. 3. Savery's Steam Pump

and the weight of the air presses the piston down. *F* is an outlet pipe, which was opened occasionally to permit the water and condensed steam to run out of the cylinder. It had a valve opening outward so as to permit the water to run out, but kept the air from coming in during the down stroke of the piston.

Savery had a patent which gave him all rights to engines run by fire, so that Newcomen and Cawley went in with him. They erected one of these engines in 1712. The place of erection is unknown, but that it was in the year 1712 is undisputed.

These engines were more successful than those of Sav-

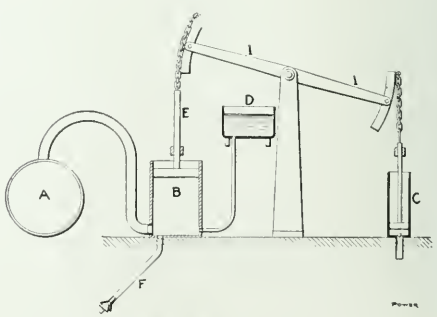


Fig. 4. Newcomen's Pumping Engine

ery and were used in many mines, upon estates and, in some cases, to pump water for towns and to drain low lands. This engine did away with the great pressure necessary in Savery's engine, because they only needed enough steam to overcome the pressure of the air, and water could be pumped against considerable heads by using water pistons of comparatively small area.

The first steam engine operated in America was one

of these Newcomen pumps, installed in 1753 at Schuyler's Point, on Newark Bay, in New Jersey by Josiah Hornblower.

The great trouble with this engine, from the engine boy's standpoint, was that he must stay and turn the valves on and off when he would rather be playing. One of these youths, Humphrey Potter is said to have devised a system of levers by which the engine worked them itself, but whether or not he was allowed to run and play or other work was found for him has not been recorded to the writer's knowledge.

This, then, was a practical steam engine, fifty years before Watt's, and 1912 passed by without any recognition of its bicentenary. It was while working upon one of these engines, at the University of Glasgow, that Watt became interested in them and his improvements followed. He found that if he used more water to condense the steam, he gained more power, but it took more fuel since he must reheat the sides of the cylinder. To overcome this, he condensed the steam in another cylinder or condenser. He also thought that steam could be used to better advantage than air in making the piston descend. He then made the engine double-acting.

This, then, is the history, in short, of the steam engine, and while we celebrate the centenary of the invention of Fulton's steam boat and the launching of the "Comet," we have let pass the true birthday of that great factor in the world's history, the piston steam engine.

The Joys of Monotony

That there is a mental monotony in the performance of the same operation day after day and year after year is denied by Prof. Münsterberg, the well known Harvard psychologist, who has made an interesting study of the subject and gives examples taken from an electric lamp factory.

It was Müsterberg's habit, when visiting a factory, to select what seemed to him the most tiresome job possible, and then study its effect upon the employee. The prize job appeared to be that of a woman who for 12 years had packed incandescent lamps in tissue paper. She packed on an average 13,000 lamps a day—about 25 lamps in 42 sec. And she denied its monotony. Her interest was held in what she called the continuous variation of the work, such as grasping the lamp or paper a different way, or studying the unevenness of the packing, or her mood for the work.

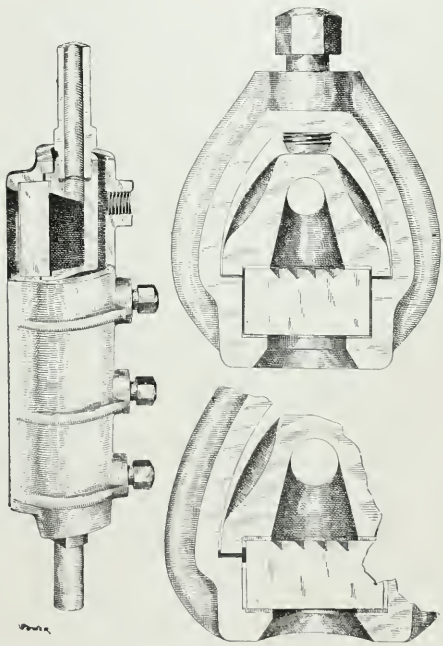
The *Bulletin* of the National Electric Light Association, from which this information is gathered, says that "even in the most uniform and stereotyped occupations, room is left for interest in the work, for thought, for self-sufficiency to a higher degree and, in almost every case, the chance of improvement in the means, the material, etc.

"In our central-station field, many of the younger men, and especially those who come into it without acquaintance with its history and evolution, seem to think that many of the tasks, and much of the work they do are monotonous; but they will not be much older before they discover that the monotony is superficial, the variety eternal. There is not one single thing in the central-station industry that cannot be done better, or made cheaper, or become more perfect or give fuller service than it does today, and in that way lies infinite opportunity for every one of us."

Klinger Water Glass

This glass consists of a brass body and a separate brass back piece, the latter including the steam and water cavity. The glass is held between these two parts and is gripped by pressure obtained by four setscrews, equally spaced on the back of the body. The general form and arrangement of this construction is shown in the illustrations.

Three gaskets have been introduced between the steam space and the face of the glass and so arranged that the steam must work by each successively before a leak can develop. The two gaskets on the front and back of the glass are of fiber $\frac{1}{32}$ in. thick and the construction allows a liberal width of seat on the metal. The third, a $\frac{1}{16}$-in. gasket of elastic material, is between a lip on the back piece and the main body, and comes at the side of the glass about one-quarter of the distance from the back. This is formed so as to seat against the glass, as well as between the lip on the back piece and the body.



Klinger Water Glass

Its elasticity is such as to permit any unevenness in the thickness of the glass to be compensated and give an equal pressure on the fiber gaskets at the top and the bottom throughout the full length, while, at the same time, the elastic gasket will also be steam-tight. The water shows black and steam white. The connections are of the proper size and form to permit of it being attached to a boiler without any changes in the fittings.

The Jerguson Manufacturing Co., 10 Post Office Square, Boston, Mass., is the manufacturer.

The world's wealth so far as expressed in stock-exchange securities is $115,800,000,000, in which the United States is represented by over twenty-five billion.

Reciprocating Pump Curves

By A. M. Daniels

SYNOPSIS—Description of the construction and use of curves for determining the size of reciprocating pumps required under given conditions.

The curves of the accompanying diagrams have been constructed to facilitate determining the size of pumps necessary to fulfill certain requirements.

Method of Construction

In constructing the curves, reference has been made to numerous pump catalogs, and, since they show no great variation as to revolutions or double strokes per minute or in velocities allowed in the different pipe sizes, in some cases a mean value has been used.

Curve 1. Since 100 ft. per min. is generally considered a good mean value upon which to base capacity calculations, this curve has been laid down on that basis with abscissas as stroke of pump in inches (found at the top of the diagram) and ordinates as revolutions per minute or double strokes (found on the right of the diagram).

Curve 2. In studying the various pump catalogs, it was observed that for a pump of a certain diameter water cylinder, a certain stroke and a certain piston speed, if the stroke be increased for the same size water cylinder, the pump may then be run at a higher piston speed than was allowable with the shorter stroke. The pump makers claim that this is for the reason that it is not reversed so often. Therefore, Curve 2 has been plotted to read actual revolutions or double strokes for pumps of given strokes, the abscissas being strokes in inches (found at the top of the diagram) and ordinates being revolutions or double strokes (found at the right of the diagram).

Curve 3. Having plotted Curve 2 to agree with the pump makers' practice, Curve 3 has been laid down to show the corresponding actual piston speeds plotted from the equation, piston speed = 2 × r.p.m. × stroke (feet). The abscissas for this curve are strokes in inches (found at the top of the diagram) and the ordinates are feet per minute (found at the right of the diagram). This curve clearly shows the increased piston speed due to the stroke being lengthened. For example, suppose two pumps of the same water cylinder diameter, one with a 9-in. stroke and the other an 18-in. stroke. From this curve it is seen that for the 8-in. stroke pump, the piston speed would be 86 ft. per min., while the stroke of the 18-in. gives a piston speed of 120 ft. per min.

Curve 4. This curve is based upon a piston speed of 100 ft. per min. and corresponding capacities for different sizes of water cylinders, capacities being in gal. per min. The abscissas are diameters of water cylinders in inches (found at the bottom of the diagram) and the ordinates are gal. per min. (found at the left of the diagram).

Curve 5. This is a velocity curve and is based upon mean values of velocities in suction pipes in terms of their diameters. The mean values were estimated from the catalogs as velocity = $164\ \sqrt{D}$. Using this equation, the curve was plotted with abscissas as diameter of suction pipe (found at the bottom of the diagram) and ordinates as velocity in ft. per min. (found at the left of the diagram).

Curve 6. This also is a velocity curve and is similar to Curve 5. This curve gives velocities in the discharge pipe when the velocities are based upon the mean value, as derived, of velocity = $200\ \sqrt{d}$. The abscissas and ordinates are the same as for Curve 5.

Curve 7. Using the velocities in the suction pipe of $164\ \sqrt{D}$ and calculating the capacity in gallons per minute from the equation: quantity = area × velocity, this curve has been constructed with abscissas of diameters of suction pipes (found at the bottom of the diagram) and ordinates of gallons per minute (found at the left of the diagram).

Curve 8. Using the velocities in the discharge pipes of $206\ \sqrt{d}$ and calculating capacities as for Curve 7, the construction of this curve is similar to the construction of Curve 7.

Application of the Curves

Example 1. *Knowing the stroke and diameter of a water cylinder to find the capacity.* If a 16-in. stroke pump with a water cylinder 7 in. in diameter had a piston speed of 100 ft. per min., we could obtain the capacity directly from Curve 4 by reading the capacity of a 7-in. diameter as 200 gal. per min. But this is not correct as Curve 3 shows that for a 16-in. stroke pump the piston speed, instead of being 100 ft. per min. is 113.3 ft. per min., and since

$$\frac{\text{Actual piston speed}}{\text{Piston speed 100 ft. per min.}} = \frac{\text{actual capacity}}{\text{capacity for 100 ft. per min.}}$$

then for this case we should have

$$\frac{113.3}{100} \times 200 = 226.6 \text{ gal. per min.}$$

To determine the diameter of suction pipe, Curve 7 is referred to and for 226.6 gal. per min. the diameter is found to be $4\frac{1}{4}$ in. Similarly, the discharge pipe is found from Curve 8 to have a diameter of $3\frac{3}{4}$ in. (In reading pipe sizes the nearest $\frac{1}{4}$-in. pipe size larger than shown where the curve cuts the line is taken.) The corresponding velocities in these pipes will be obtained from Curve 5 for the suction and Curve 6 for the discharge. For the $4\frac{1}{4}$-in. suction pipe there is found a velocity of 340 ft. per min. and for the $3\frac{3}{4}$-in. discharge pipe a velocity of 405 ft. per min.

Example 2. *Knowing the capacity required, to find the size of the cylinder and other quantities.* Suppose the pump must deliver 500 gal. per min. First, the stroke must be assumed. This may be fixed by conditions of usual practice. Assuming a stroke of 8 in., if the piston speed were 100 ft. per min., Curve 1 shows that the pump would have to run at 75 r.p.m., but to determine the revolutions corresponding to those actually allowed, Curve 2 shows, for an 8-in. stroke 60 r.p.m. and Curve 3 an actual piston speed of 80 ft. per min.

The next step is to determine the size of the water cylinder. For a piston speed of 100 ft. per min., from Curve 4, corresponding to 500 gal. per min., the diameter indicated is 11 in. This is not correct though, for this pump is to run at a piston speed of only 80 ft. per min., therefore, to deliver 500 gal. the cylinder must be larger than 11 in. and, since for a given capacity, the cross-sectional area or square of the diameter must vary inversely as the

piston speed, i.e., the square of the diameter should $= 11 \times 11 \times \frac{100}{80}$, and the cylinder diameter would be

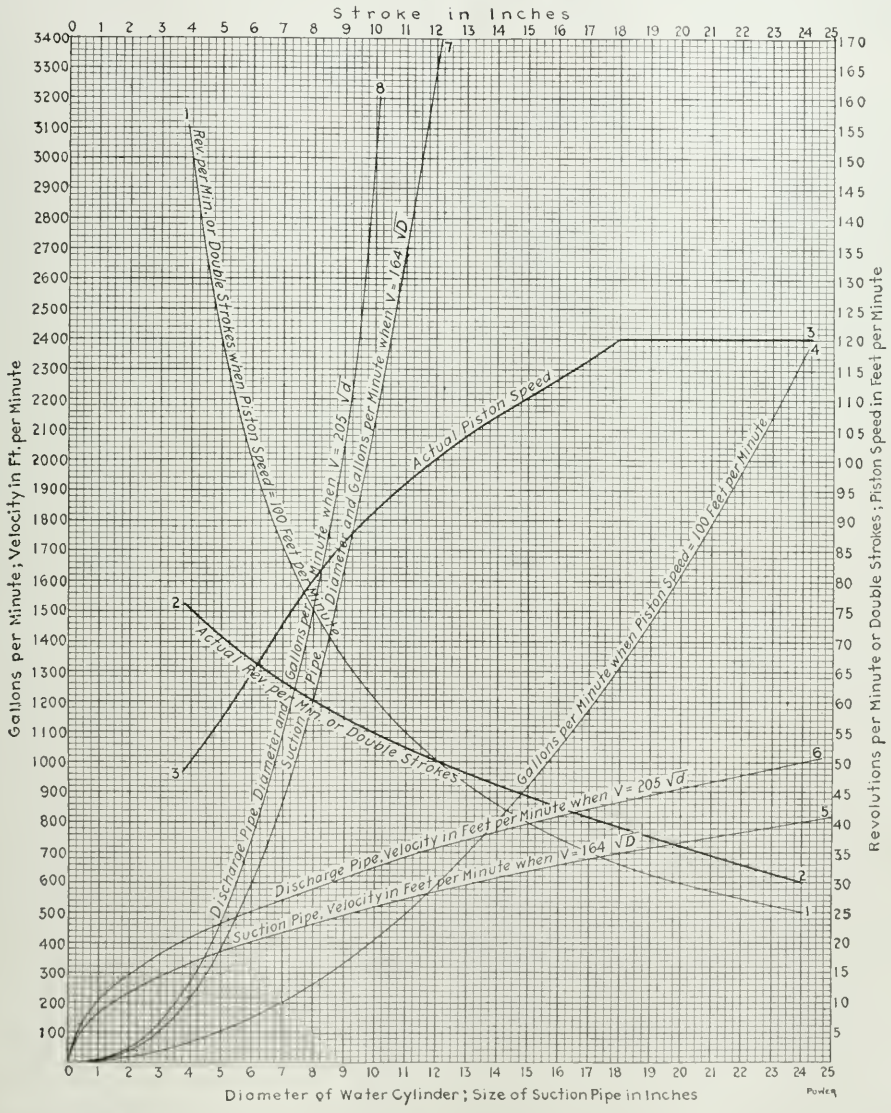
$$\sqrt{11 \times 11 \times \frac{100}{80}} = 12.29$$

or about $12\frac{5}{16}$ in.

Having the capacity, the diameters of suction and discharge pipes and respective velocities may be obtained as in Example 1.

EXAMPLE 3. *Knowing the cylinder diameter and stroke, to determine the capacity for any other stroke.* Having a pump of 7-in. water cylinder, with a stroke of 18 in., what will be the capacity if only a 9-in. stroke is used?

First of all, Curve 2 shows that having an 18-in. stroke, the pump must make 39 r.p.m., and have a piston speed, Curve 3, of 120 ft. per min. Curve 4 gives a capacity for a 7-in. cylinder and 100 ft. piston speed of 200 gal. per min.; but since this piston speed is 120 ft. per min., the capacity must be increased in the ratio of 120 to 100, or capacity $= 200 \times \frac{120}{100} \times 240$ gal. per min. But Curve 2 shows that if the stroke is shortened to 9 in., the pump must be run at 57 r.p.m. and then have a piston speed of about 86 ft. per min. Consequently, the capacity of 200 gal. per min. will be decreased in the ratio of 86 to 100, or capacity $= 200 \times \frac{86}{100} = 172$ gal. per min., i.e., a difference of 68 gal. per min. in favor of the longer stroke with 18 less r.p.m.


Stroke in Inches
Gallons per Minute; Velocity in Ft. per Minute
Revolutions per Minute or Double Strokes; Piston Speed in Feet per Minute
Diameter of Water Cylinder; Size of Suction Pipe in Inches
Rev. per Min. or Double Strokes when Piston Speed = 100 Feet per Minute
Actual Piston Speed
Actual Rev. per Min. or Double Strokes
Gallons per Minute when V = 205 √d
Gallons per Minute when V = 164 √D
Diameter and Gallons per Minute when V = 164 √D
Gallons per Minute when Piston Speed = 100 Feet per Minute
Discharge Pipe, Diameter and Gallons per Minute when V = 205 √d
Discharge Pipe, Velocity in Feet per Minute when V = 205 √d
Discharge Pipe, Velocity in Feet per Minute when V = 164 √D
Suction Pipe, Velocity in Feet per Minute when V = 164 √D
Power

ELECTRICAL DEPARTMENT

Three Wire System with Rotary Balancer

By A. M. Bennett

The advantages in the use of the direct-current, three-wire system are well known, and have led to its general adoption for the transmission and distribution of electrical energy from central stations, as well as in connection with the isolated-plant service. In fact, there is no class of service having a fairly well divided lighting and power load, in which this system cannot be economically and effectively employed. The two voltages existing on the system, usually 110 and 220, meet the requirements of lighting and power service respectively in an ideal manner, inherent characteristics of lamps requiring a low voltage, while motors work equally as well on the higher

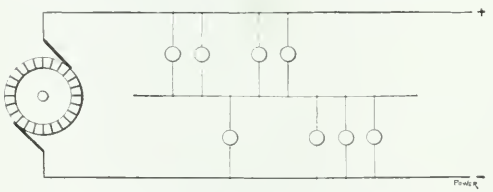


Fig. 1. Possible Arrangement if Load Were Always Balanced

voltage, and in the larger outputs will be found to cost materially less. The combination affords a convenient means of operating variable-speed motors on a two-voltage system, the motors being connected across the outer mains, their low-voltage connection being made to the neutral.

However, it is the saving in line copper by the use of the three-wire system that is the chief factor responsible for its promotion and extension, this saving being due to the fact that the energy, although used at the lower voltage, is transmitted at the higher. In a two-wire system this energy would have to be transmitted at the voltage at which it was used, which to correspond to that of the three-wire system, would be the lower voltage. In this case, therefore, with the same output, the current flowing would be twice that in the former case. As the line loss in watts equals the square of the current multiplied by the line resistance, it is evident that with a given loss, the resistance in the former case can be four times that in the latter, or the weight of copper one-fourth. This takes account of two mains only in either system. In a three-wire system the middle wire or neutral as it is called need be only large enough to carry the unbalanced current, which varies in different installations from 10 to 25 per cent. of the total load. Figuring liberally for the neutral wire by making it one-half the size of the outside mains, the weight of copper in the three-wire system becomes five-sixteenths that in the corresponding two-wire system, with the same line loss in each case.

If the load on a two-wire system were such as to be always divisible into two equal groups, the apparatus comprising this load could all be of the lower voltage, and the two groups connected in series across the mains of a system generating the higher voltage, with a third line connecting the inside ends of the individual loads, as shown in Fig. 1; this would serve to distribute the current from one load group to the other. Such an arrangement would permit advantage to be taken of the low voltage for lamps, and of the higher voltage for distribution, with its consequent saving in copper, and would insure a voltage balance on the two sides of the system as long as the resistance of the combined load on each side remained the same. Where there is a divided load, however, it is impossible to proportion and control this so exactly, that at all times there is the same load on each side. In the scheme shown by Fig. 1, if the resistance on one side of the system changes, due to switching off part of the load, the combined resistance of the two sides also changes, and with it the current flowing through the connected apparatus. But, inasmuch as the groups on the two sides are in series, the same current must flow through each, irrespective of the fact that under the changed conditions, the amount of current required by the two groups will be different.

For example, consider eight 25-watt, 125-volt lamps connected across 250 volts, as in Fig. 1. The resistance of each lamp is approximately 625 ohms, and their combined resistance is

$$\frac{625 \times 2}{4} = 312.5 \text{ ohms}$$

This across 250 volts, gives rise to a current of 0.8 amp.,

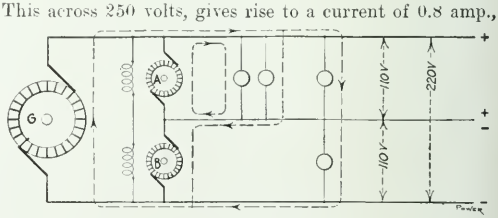


Fig. 2. Showing Distribution of Unbalanced Load

and as there are four paths in multiple, each consisting of two lamps in series, each path will take 0.2 amp., which is the normal current for such lamps.

Now consider the effect of turning off a lamp on one side of the system. The combined resistance of the remaining seven will be

$$\frac{625}{4} + \frac{625}{3} = 364.6 \text{ ohms}$$

which at 250 volts allows approximately 0.68 amp. to flow. As this divides among four lamps on one side, each must take 0.17 amp., or 85 per cent. of its normal current. On the other side each lamp will take one-third of the total current flowing, or approximately 0.23 amp., which is 15 per cent. in excess of normal current. Neither

set of lamps is burning under normal conditions, nor can the voltage on the system be raised to allow more current through the dimly burning lamps, without correspondingly increasing the current taken by those that are already burning too brightly. It is necessary, therefore, to so arrange the source of power, that a voltage of one-half that between the outside mains be provided for the third wire, in order that the load on one side may be independent of that on the other. In other words, the load on each side must be at an independent voltage. To this end various methods have been devised, of which two only are in general use at present; these are the three-wire generator,* and the rotary balancer.

The rotary balancer in its most common form consists of two like machines with their shafts coupled together, and their armatures connected in series across the mains of an ordinary two-wire system, as in Fig. 2, where G represents the main generator, and A and B the two machines comprising the balancer. Each of the latter is wound for one-half the voltage of the main generator, and their combined rating in amperes is made equal to the probable difference in load between the two sides of the system. This is known as the unbalanced load, which is carried by the neutral wire, taken off from the balancer at the point where the two armatures connect.

Of course, it will be understood that apparatus designed for the voltage between the outside mains, can be connected across these mains, without affecting in any manner the unbalanced load of the system.

The action of the balancer is as follows: When the load on the system is balanced, that is, the same on both sides, the two machines run as motors in series across the outside mains. No work is done, and no current is used except that necessary to overcome the losses of the machines running free. As soon, however, as one side of the system becomes more heavily loaded than the other, this action of the balancer ceases. The drop in voltage on the side having the heavier load will be the greater, and the voltage impressed on the machine on this side will be reduced. The machine connected across the lighter loaded side, having the higher voltage, will now tend to run faster than the other, and drive it as a generator. The motor will act as a load on its side of the system, lowering the voltage on that side, while the generator will supply current to, and raise the voltage on the heavily loaded side. The combined current of the two machines is equal to the unbalanced load of the system, and the effect on the voltage is to restore the balance.

As the unbalanced load may shift at any time from one side to the other, it is evident that this action of the balancer must also shift. Either machine may at one instant be operating as a motor, and at the next as a generator. As the direction of rotation is always the same, it is impossible at any time to tell, without knowing how the load is balanced, which is the motor, and which the generator.

It is usual in speaking of the current in the balancer, to say that one-half the unbalanced load is taken by each machine. This would be true if no losses existed in the machines. As these losses must be supplied by the motor, the actual division of current is such, that that taken by the motor is in excess of that in the generator by the amount of the losses in the two armatures. This division of current can best be shown by an example, and for simplicity the losses in the two machines will not be considered. In Fig. 3 with ten, 60-watt lamps on the positive side and six on the negative side, the total load on the main generator is

$$\frac{16 \times 60}{240} = 4 \ amp.$$

This is the current going out at the positive brush, and returning by the negative. The load on the positive side is

$$\frac{10 \times 60}{120} = 5 \ amp.$$

and that on the negative side is

$$\frac{6 \times 60}{120} = 3 \ amp.$$

The unbalanced load is 2 amp. Therefore, B will run as a motor, drawing its power from the main generator, and will drive A as a generator, which in turn will furnish current to the heavily loaded side. The current in each machine will be 1 amp., that is, the unbalanced load is divided between the two machines. The one ampere taken by the motor is added to the 3-amp. lamp load on that side, making the 4 amp. furnished by the main generator. These 4 amp. have added to them the 1 amp. furnished by the generator half of the balancer set, making the 5 amp. required on the positive side of the system.

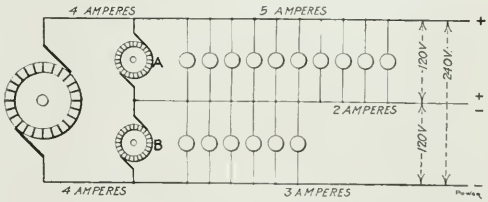


Fig. 3. Unbalanced Load

The direction of current flow with unbalanced load can be seen from inspection of Fig. 2, being shown by the arrows on the dotted lines.

Balancer sets may be either shunt or compound wound. A common method of connecting a shunt-wound balancer is shown in Fig. 2, the fields of the two machines being in series across the mains of the system. In this case both machines have the same field strength, and the counter electro-motive force generated by each is the same. The regulation is poor, due to the drop in speed of the motor with increasing load, and for this reason this method of connection is not to be recommended.

Regulation in a shunt-wound balancer may be improved by crossing the fields, and connecting their middle points to the neutral, as in Fig. 4. This puts the motor field across the voltage on the generator side of the system, and the generator field across that on the motor side. With a balanced-load condition the effect of this method is no different to that of the straight connection shown in Fig. 2, but with an unbalanced load the motor field, being subjected to the lower voltage of the generator side, is weakened, the speed of the set is raised, and with it the voltage of the generator. This latter effect is still further increased as the fields of the generator are

*The three-wire generator was fully discussed in an article by the author in the Oct. 8, 1912, issue.

strengthened at the same time by being connected across the side of the system with the higher voltage.

Even with the increase of voltage thus obtained the voltage unbalance on the two sides of the system is not fully compensated for, and resort must be had to other means to raise the generator voltage with an increasing unbalanced load. This can be done by the addition of a series winding to the field of each machine, which must be connected so that in the motor it opposes the shunt field, and in the generator strengthens it. As the unbalanced load then becomes greater, and with it the drop in voltage on the heavily loaded side, so the effect of these series windings becomes greater. The motor field is weakened, and the speed increases as in the case of the shunt balancer just described. This combined with the strengthening of the generator field, raises the voltage of the generator, compensating for the increased voltage drop on the system.

There are various methods of connecting the series windings into the circuits of the system, the most widely used of which are shown in Figs. 4, 5 and 6.

In Fig. 4 these are shown connected in the neutral circuit. The same current flows through each winding, and the weakening effect on the motor field is the same as the strengthening effect on the generator field. The operation of the set is very stable under all conditions of load.

The connection shown in Fig. 5 where the series winding of each machine is in the armature circuit, is open to the objection that with increasing load the operation of the set becomes unstable, due to excessive field weakening of the motor. In this case the same current does not flow through both windings, as the neutral current divides on reaching the balancer, the larger portion passing to the motor as previously explained. The differential effect on the motor field is, therefore, greater than that in the preceding case, and its field flux is decreased at a greater rate than the generator flux is increased. This action becomes aggravated on overload, and the result is excessively high speed with poor regulation.

By crossing the series fields, as in Fig. 6, this objection is overcome. The motor current passes through the generator field, and the generator current through the motor field. Hence, the compounding effect of the generator field is greater than the differential effect of the motor field, due to the larger current passing through the former. The necessary voltage balance is obtained, therefore, with less speed increase, and the action of the set becomes even more stable than in the case of Fig. 4.

Where only one balancer set is to be used, a single regulator in the shunt field circuit of one of the machines, as at *R*, Fig. 4, will suffice for adjustment of the voltage. But if two or more sets are to be operated in parallel, each should be provided with two regulators to properly adjust the voltage. These should be connected as in Fig. 5, or a three-point regulator may be used, as in Fig. 6. This latter is preferred, as manipulation of one rheostat is easier than two. Adjustment by rheostat is made under no-load condition. If further adjustment is necessary under load, it should be done by shunting part of the current from the series windings.

A starting rheostat connected in the armature circuit of one of the machines permits the set to be started and brought up to speed.

A form of balancer sometimes used where the load to be taken care of is small, consists of a machine, the armature of which has two like windings, each connected to its own commutator. This rotates in a single field. On this account voltage adjustment by field regulator is not possible, as the same field flux affects both armature windings alike. A series winding is not of use for the same reason. It can be readily seen that, due to lack of voltage adjustment and compounding, regulation with this arrangement will be poor.

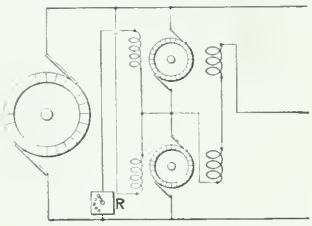


Fig. 4

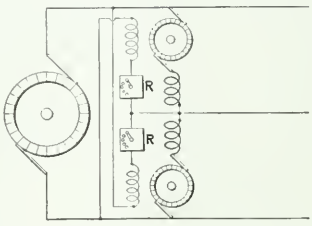


Fig. 5

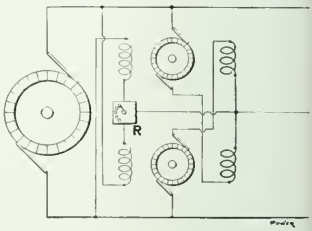


Fig. 6

Various Field Connections for Regulation in Compound-Wound Balancer

The switchboard equipment for balancer sets, in addition to the starter and regulator previously mentioned, usually consists of a double-pole and a single-pole switch, and a central zero ammeter. A voltmeter switch may be provided by means of which the voltage across the outside mains of the system, and also between either main and the neutral may be read from the voltmeter on the main generator panel. The double-pole switch is placed in the lines connecting the set to the mains of the system, and the single-pole switch in the neutral.

If a protective device, such as a circuit-breaker, is used in the neutral, it should be arranged to also trip the main generator breaker. Otherwise, if from overload on the neutral or a short-circuit, this breaker should open, the lamps on the system would be thrown in series across the outside mains, and they would burn out before the neutral circuit could again be established. Such a device in addition to the protection it affords the load on the system, is also a safeguard to the balancer set. For the reason just stated fuses should not be used in the neutral, unless they are of a capacity to withstand any probable overload on this circuit.

For individual feeder circuits, three-pole switches are all that is required, though in many cases three-pole circuit-breakers are used, with a coil in each outside wire. These connections are shown in Fig. 7.

In starting up the balancer, the neutral switch and those to the feeder circuits should be open. The double-pole switch should then be closed and the set brought up to

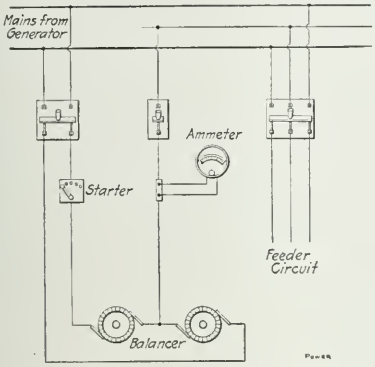


Fig. 7. Switchboard Connections for Balancer Set

speed by means of the starter. The neutral switch can then be closed, and after it, the various feeders can be connected to the main circuit.

Mr. Bryant's Motor Trouble

In regard to Mr. Bryant's inquiry in the Feb. 25 issue, I would say that it is indeed a peculiar case of motor trouble. He states that, although the motor does not work properly, each separate part is in good condition and as it should be, with the exception of a 20-volt ground which, however, he does not believe to be the cause of the trouble.

A ground of 20 volts on one phase only, will not interfere with the working of an induction motor, as I have known motors to carry a full load with a ground on one phase equal to the rated voltage of the motor.

Mr. Bryant's statement, "The stator windings had just been renewed and the cross-connections were made in accordance with the manufacturer's drawing for Y-wound motors of this type" is not quite clear. It may be that he used a drawing for Y-wound motors of that type, but that the drawing was not for that particular motor. The term Y-wound is rather indefinite as it may mean either a one-circuit Y or a two-circuit Y connection. All motors of the same type and number of poles do not have the same coil connections as the voltage also has to be considered.

I would suggest that a drawing of the coil connections for that particular motor be procured from the manufacturers (giving them the motor number, r.p.m., type and voltage) and then see if it compares with the way the motor is connected at present.

If the supply voltage and frequency corresponds with that called for by the nameplate, and the motor is not overloaded, the cause of its not coming up to speed and heating would very likely be due to excessive friction in the motor itself or to improper coil connections. As the coils have just been renewed and reconnected, it would seem quite probable that the trouble is in them.

L. H. Holtzapple.

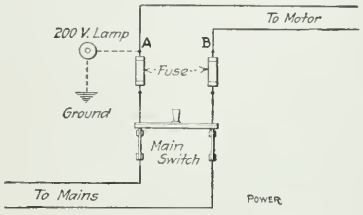
Winona, Mich.

Induction Motor Refused to Start

A 7-hp., 400-volt induction motor, working on a 40-volt, single-phase, 3-wire system with a grounded neutral refused to start one morning. I first tested at *A* and *B* through a 200-volt lamp to earth, the lamp lighting on each side which showed conclusively that current was on.

Next, I searched for loose connections, but could find none, and as a last resort grounded one side at the fuse and tried the motor at 200 volts between the outer line *A* and the earth. The result was that the motor started slowly and after a considerable time, in comparison with that usually required for starting, ran up to speed but stopped as soon as any load was put on.

This gave a clue to the trouble and to verify it I put



Main Switch and Fuses

two 200-volt lamps in series across *AB*, and no light showed, there being no voltage between the mains, although each showed 200 volts to earth; this proved that *A* and *B* were of the same polarity.

There had been extensions to the mains just previous to this and a mistake had been made in connecting up, both the outer wires being put in parallel. The lighting being on the 200-volt circuit remained unaffected as there were 200 volts between the outer wires and the neutral.

L. H. Field.

N. Adelaide, Australia.

Charging Dry Batteries

In the Feb. 18 issue, Mr. McGerry describes a method of recharging dry batteries. During the past week I have tried out some 25 batteries as per the directions given, taking care to follow them very carefully. I was able to get as high as 12 amp. out of one and lower readings out of the rest, but after allowing the batteries to stand 10 to 12 hr. they were as dead as ever.

I would like to inquire if Mr. McGerry used any acid or other material in the water with which he soaked his batteries. Possibly he may be able to give some reason why all the batteries failed to resurrect themselves. I made a very careful inspection of the zinc covers before attempting the experiment.

R. S. King.

Ellendale, N. D.

In a recent issue we mentioned an instructive little device called the "Current-O-Scope" which Fairbanks, Morse & Co. were distributing for 25c. apiece. Our readers will be interested to know that the above company has now decided to send these to engineers, free of charge, in return for information regarding the equipment under their care.

GAS POWER DEPARTMENT

Jacket Water Requirements of Internal Combustion Engines

By Reginald Trautschold

Tests and practice have indicated that a well designed internal-combustion engine operates most economically when its jacket water is discharged at the highest temperature attainable without serious generation of steam in the engine jackets, a temperature of about 185 or 190 deg. F.; also, that the temperature of the jacket-water supply has little effect upon the fuel consumption of the engine provided a difference of at least 105 deg. is maintained between the temperatures of the incoming and the outgoing water. To maintain a suitable temperature of discharge, then, the quantity of water supplied to the jackets and the temperature at which it is admitted are the two governing conditions.

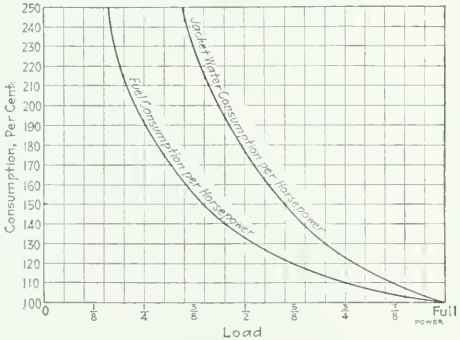


Fig. 1. Effect of Load on Fuel and Jacket-Water Consumption

Considering first the consumption of jacket water, not only does the load on the engine affect the quantity required, but the efficiency of the engine under the load must also be taken into consideration. Considering both fuel and jacket-water requirements as unity at full load, when the engine operates at its best efficiency, the increase in fuel and jacket-water requirements for the best results in a typical case are given in Table I, which is graphically shown in Fig. 1. At three-eighths load, about the lightest load that an engine in an efficient installation is called upon to carry, the fuel requirements per horsepower are 54.5 per cent. greater than when operating under full load, while the jacket-water requirements are 2.85 times as great as under the more efficient operation. This relation is about constant regardless of the temperature of the water fed to the jackets, provided it is not much more than 80 deg. F. above which temperature of supply the generation of steam in the jackets commences to become serious before the efficient temperature ranges of 105 deg. is attained, resulting in reduced jacket efficiency and a corresponding increase in fuel consumption.

The temperature of the water supply to the jackets has an effect, however, upon the consumption of jacket water, for the cooler the water the longer it can be retained in the jackets, water of a higher temperature reaching the advisable temperature of discharge through a lesser temperature range. The minimum practical temperature of the jacket-water supply is about 35 deg. F. while its maximum temperature is about 80 deg. Considering the required quantity of jacket water at an entering temperature of 35 deg. as unity, the quantity of jacket water required at other temperatures of supply and under various engine loads is given in Table II. In installations where the jacket water is used over and over, the rate of consumption is of secondary importance as, within reasonable limits, this simply necessitates increasing or decreasing the mean velocity of the water through the jackets. Where water is sufficiently cheap to permit its being wasted, the supply temperature is usually relatively low and the saving that accrues from low temperature of supply may or may not be sufficiently great to take into consideration. The former practice, that of cooling the water and using it over again, is the more common and, as the rate of consumption is of little importance, the effect of supply temperature on the consumption of jacket water is of interest. Considering the requirements at full load as unity, this relation is graphically shown in Fig. 2, and, although little difference in the requirements of an engine operating under at least 7/8 load is noticeable, there is considerable variation between 1/2 and 3/8 load. From full load to 3/8 load the increase in jacket-water consumption, with water supplied at 35 deg., would be 173.5 per cent., while in the case of jacket water supplied at 80 deg. the increase for the same range in load would only be 122 per cent.

TABLE I. EFFECT OF LOAD ON FUEL AND JACKET-WATER CONSUMPTION

Load	Consumption per Horsepower	
	Fuel	Jacket Water
Full	1.000	1.000
7/8	1.048	1.099
3/4	1.108	1.232
5/8	1.200	1.440
1/2	1.325	1.765
3/8	1.545	2.850

TABLE II. EFFECT OF SUPPLY TEMPERATURE ON JACKET-WATER CONSUMPTION

Temperature of Water Supply	Quantity of Jacket Water Required at Various Loads					
	Full	7/8	3/4	5/8	1/2	3/8
35 F.	1.000	1.135	1.313	1.598	2.041	2.735
40	1.030	1.165	1.343	1.628	2.071	2.765
45	1.067	1.202	1.380	1.665	2.108	2.802
50	1.108	1.243	1.421	1.706	2.149	2.843
55	1.151	1.286	1.464	1.749	2.192	2.886
60	1.198	1.333	1.511	1.796	2.239	2.933
65	1.245	1.379	1.558	1.843	2.286	2.980
70	1.295	1.429	1.609	1.893	2.336	3.030
75	1.353	1.487	1.667	1.951	2.394	3.088
80	1.422	1.556	1.736	2.020	2.463	3.157

The jacket-water requirements in gallons per horsepower at various loads and supply at temperatures for an efficient oil engine are indicated in Fig. 3; also, this may be taken as typical of internal-combustion engines operating on any fuel. A fuel low in heat value, such as ordinary city gas and producer gas, requires more jacket

water for power developed than richer fuels, but the effect of load and jacket-water requirements on fuel consumption is about the same. In any event, the importance of carefully regulating the jacket-water supply to conform with the engine load is evident, for the temperature range of the jacket water is directly dependent upon its supply.

In installations where the cooling jacket water is used repeatedly, there is no appreciable gain in reducing the temperature of the supply to much below 80 deg. F. In fact, at this temperature there is an advantage, other than that of reducing the cooling facilities that must otherwise be provided; for, the supply of jacket water when the engine is operating under light load does not have to be relatively increased as much as when the water supply is cooler, facilitating regulation, or rather minimizing losses in efficiency should the regulation not be sufficiently sensitive. In installations where the jacket water is wasted, the supply may be advantageously as near 35 deg. as possible and thus decrease the consumption, even though the relative increase in jacket-water

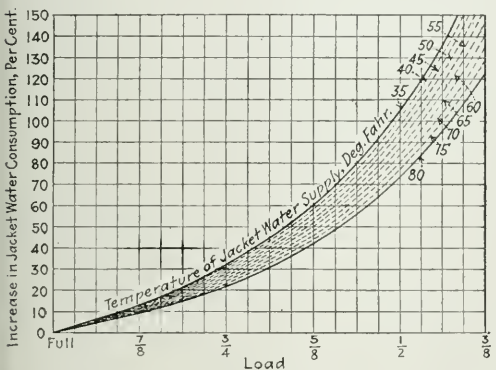


FIG. 2. JACKET-WATER REQUIREMENTS AT DIFFERENT LOADS AS DEPENDENT ON TEMPERATURE OF SUPPLY

requirements from full to light loads is greater and the regulation, therefore, necessarily more sensitive than when using warm water.

Accurate hand regulation of the water supply to the jackets is naturally difficult and in many installations automatic regulators can be advantageously installed. The saving in fuel consumption that is possible through the use of such controllers or regulators depends, of course upon the variations in engine load and upon the attention of the operating engineer to the jacket temperatures without such automatic devices, a fairly constant load, and careful engineers discounting the value of a jacket-water controller as a money saver.

In the "London Times," C. E. Stromeyer, chief engineer of the Manchester Steam Users Association, gives the following table as showing the prices of the various fuels. Each column gives those prices at which equal economy could be had if any of the power processes mentionad are used:

Fuel	Prices per Ton					
Crude oil for Diesel engine	$8 52	$9 73	$10 95	$12 17	$1314	39 $60
Gasoline for gasoline engine	10.70	12 17	13 63	15 09	16.79	18.25
Coal for producer-gas engine	2.79	3.25	3.65	4.02	4 50	4.87
Coal for gas-fired boiler	2 07	2.31	2.56	2.92	3.16	3.41
Coal for steam engine	2 43	2 92	3.29	3 65	4.02	4.38

Removing Piston Rings

BY A. L. BRENNAN, JR.

It is invariably found that unless proper precautions are taken in removing piston rings that the operator will be confronted with one or more broken rings. This is because the rings are of cast iron, which is limited in elasticity; consequently care must be taken not to "spring" the rings too much when opening them to clear the grooves. Piston rings that have become badly gummed, due to faulty lubrication and fit tightly in their grooves or are rusted in, will need particular attention. In this case it is always advisable first to soak the piston in kerosene for a few hours. This softens the carbon or rust and frees the rings; but if the pistons are in a particularly bad condition it may be necessary to pound the rings loose—an operation which should be performed only with a wooden or lead hammer. Never hit a piston or ring with a steel hammer; however, a piece of wood may be placed against the rings and the wood tapped with a hammer.

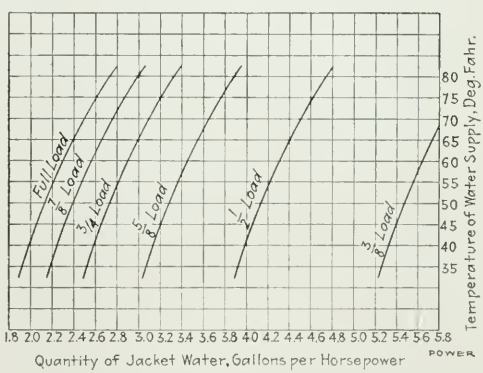


FIG. 3. EFFECT OF WATER-SUPPLY TEMPERATURE ON JACKET-WATER REQUIREMENTS

After the rings have been soaked in kerosene or otherwise freed of excessive carbon so that they work freely in their grooves they will be ready for removal. Usually about the only tool an operator has at hand that will help in the removal of the rings is a screwdriver; except in rare instances this is sufficient when used in conjunction with three or four strips of tin or sheet iron, the number and size depending upon the size of the piston. For small motors strips of tin as long as the piston and from ¼ to ½ in. should be used as follows: The ends of the top ring should be worked apart by gently forcing the end of the screwdriver into the "cut"; when this is done one side of the ring will lift and at this point one of the strips of tin should be inserted, then by following the tin with the screwdriver, the tin can be worked around until it is 180 deg. from the cut. It is not well to pry up the end of the ring at the "cut" far enough to clear the center of the ring, for in all probability this will snap off a piece of the ring. After the first strip of tin or iron is in position the same steps should be followed when inserting the other strips which should be placed at 90 deg. apart when four are used, or 120 deg. apart when three are employed. When the

strips are all in position the ring will have been elevated from its groove and can easily be removed, the strips of tin not only holding the ring out of its groove but acting as guides as well.

The most convenient way to handle a piston when removing the rings (if the piston is free from the engine) is to have it securely clamped in a vise, this will usually call for the piston being in an upright position; the jaws of the vise being in contact with the connecting-rod. In this case it is advisable to remove the lowest ring first, for, otherwise, difficulty may be experienced while removing these rings last, as they would have a tendency to drop into the grooves of the other rings should the guide strips slip.

After removing the rings they can be easily cleaned with emery cloth. The grooves in the piston should be looked over and any deposits removed by employing long, narrow strips of emery cloth.

When replacing the piston rings it is advisable to place the top ring in position first· then the next and so on. By using the strips of tin as guides when putting the rings back little trouble will be experienced. After the rings are in place make sure that their joints are equal distances apart, for instance, if there are three rings on the piston, have their ends 120 deg. apart, or, if the piston has four rings, see that they are 90 deg. apart. Nearly all piston troubles can be avoided by suitable lubrication, that is, by employing an oil of the proper flash point, good viscosity and using about the correct amount.

Kerosene is very good for softening carbon deposits and limbering up the rings, but in most cases it is necessary to use it two or three times to get the best results. Never pour kerosene into the cylinders of a gas engine while the engine is hot, but wait until it has cooled off, for, if the oil comes in contact with the overheated metal, it will lose some of its valuable cleansing properties. After pouring about a pint of oil into each cylinder, crank the motor over several times to insure its distribution and then allow the motor to stand eight or ten hours. If this is carried out for three or four successive days, even if the motor is operated in the meantime, considerable good will result. This has reference to rings and pistons that are in bad condition. When a motor is in good condition, this should be resorted to about once a month, and in consequence it will seldom be found necessary to remove the rings.

New Oil Turbine

The English press has recently contained accounts of a new turbine of the internal-combustion type fed with oil. It is a double-flow turbine of the Parsons type, with a single admission port at the center, through which compressed air is forced at a pressure of about 960 lb. per sq.in., and at a temperature of about 1200 deg. F. Oil is then sprayed in, and burns, and immediately a spray of hot water (derived from the jacket of the last cylinder of the three-stage air compressor) follows, being at once converted into steam at high pressure; this expands through the blading in the usual way. Owing to the use of steam, the temperature in the blading is kept down, thus avoiding the troubles incidental to the exposure of the blades to excessive temperatures; in fact, the turbine has to be lagged to prevent loss of heat. The action, it will be seen, is not quite continuous, but is nearly so. The inventors are Messrs. Gavan and Leon Inrig, who have built a 65-hp. turbine of this type, running at 4000 r.p.m.

CORRESPONDENCE

An Operator's Experience with Diesel Engines

In talks with engineers regarding a change from steam to gas or oil engines, I find that the chief objection is that they are afraid the more complicated mechanism of these newer types would be too hard to learn, and that their positions would thus be endangered. My experience has been, however, that there is really but one thing to keep in mind in operating a Diesel engine and that is cleanliness; from this all the other necessary precautions follow. In wiping and polishing, one will discover nuts that have become loosened by vibration, which can be set up before any damage is done. The strainers should be cleaned once a week, which can be done while running, and I have found that the crank brasses on the engine I am operating need setting up every six weeks. The fuel nozzles show, after six months, no sign of wear. The atomizer needs cleaning every three months. In fact, dirt is the chief enemy of the Diesel engine.

The next one we order, however, will be under slightly different specifications, and here is where the prospective buyer may benefit by our experience. We shall specify that the side doors be made of aluminum, so that one man may handle them easily; that the studs holding the needle-valve gland, and the ears of the gland itself, be made heavier; that the back or piston end of the needle valve have some sort of hook or eye-bolt, so that it can be removed easily from its cage; and that the small washer used as a follower to the atomizer be screwed into the cage, and made longer, so that the excessive pressure of the injection of air will not be against the packing and the studs. Also the crank cases should have large drainage faucets to facilitate cleaning.

The regulation of the Diesel engine is excellent, but my experience does not agree with the popular belief that any kind of fuel is "good enough." Usually crude oil will be found to hold too much water in suspension. A little water passing through the atomizer, while the engine is under a heavy load, will cause the speed to vary, although the governor takes care of this at once; yet without a voltage regulator on the switchboard, this variation of the speed would cause flickering of the lights. The distillate known as fuel oil, is often too thick, especially in the winter, as it will not run of its own accord. The arrangement of the suction valve on the governor will not seat itself, except by the aid of springs, and these do not act quickly enough with the heavy fuel oil to give good results.

Kerosene is good, but costs too much. This leaves us in this locality only with the fuel, known as "Solar oil." We have found this not only the best fuel to use in the Diesel engine, but the cheapest.

Our fuel bill, formerly $28 per day of 24 hr., has now fallen to $5 for the same period.

Great Bend, Kan. JOHN PIERCE.

REFRIGERATION DEPARTMENT

Ritz-Carlton Refrigerating Plant

One of New York City's newest and best equipped hotels is the Ritz-Carlton, on West Forty-sixth St. and Madison Ave. The building is 16 stories in height and contains 400 rooms. It is supplied with heat, light, power and refrigeration by a private plant in the basement 63 ft. below the street level. In a previous issue the heating and ventilating plant was described, and the present article will deal with the refrigerating apparatus. An addition has just been made to the plant for air cooling in the hot summer months and the compressor equipment now consists of three machines, two 50-ton compressors, and a 175-ton machine for the air cooling. All similar in type, size of pipe and length, and consists of 10 sections 12 pipes high. The general arrangement of the plant and size of the piping is shown in Fig. 1.

Primarily the plant was laid out for ice making and general refrigeration, consisting of a low-pressure brine line for cooling 96 refrigerators, a high-pressure brine system for cooling 14 service refrigerators from the third to the thirteenth floor, a water-cooling system on direct expansion with a capacity to cool 500 gal. of water per hour from 76 to 40 deg. F. and a caraffe freezer for the freezing of 500 water bottles for the tables. The temperature of the brine delivered to the refrigerators is +5 deg. F. and that for the ice-cream freezers ranges between 0 and —5 deg. F.

Artificial ice is made with a modified raw-water system having a capacity of 15 tons per day of 24 hr. Three hundred-pound cakes are frozen in 14 to 16 hr., depending on the temperature of the brine and the rapidity of circulation. The cans have a double wall with ½ in. space between. The brine is circulated in this space and does not enter the tank as is usual in other systems. Air is introduced at the bottom of the can and blown upward during the process of freezing so that the agitation resulting will cause impurities in the water to drop into an extension or nonfreezing zone at the bottom of the can. The location of the ice tank is shown in Fig. 1.

Of particular interest is the air-cooling system, as there

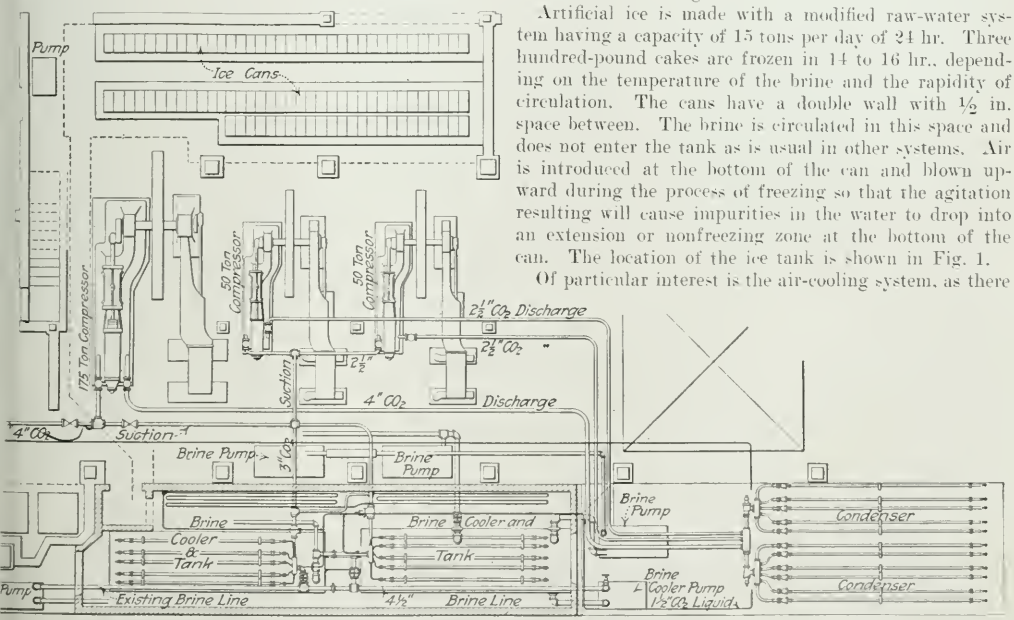


FIG. 1. ARRANGEMENT OF CO_2 PLANT IN THE RITZ-CARLTON

re Kroeschell carbon-dioxide compressors driven by simple Corliss engines; the smaller engines are 14x36 in. and he large engine 18x12 in. The machines work between suction pressure of 20 atmospheres and a condenser ressure of 62 atmospheres. All are cross connected, so hat any one compressor may be used for any service demanded of the refrigerating plant.

The condenser is of the double-pipe counter-current ype, consisting of eleven sections of 1¼- and 2½-in. ipes 20 ft. long and 18 pipes high. During the winter nonths, cooling water of 39 deg. is available, and in he summer its temperature is around 76 deg. In close roximity to the condenser is the brine cooler, which is are only a few installations of the kind in this country. The service is used for the ballroom, banquet hall and private dining rooms, and there is capacity to cool 60,000 cu.ft. of air 20 deg., with the temperature of the incoming air at 85 deg. F. and 60 per cent. humidity. The air to be cooled is conducted to an insulated room about 16 ft. wide, 12 ft. long and 7½ ft. high. Fig. 2 gives an indication of the layout. The same room is used for heating and tempering the air during the cold months and the same motor-driven fans circulate and distribute the air to the various rooms. As may be seen in the drawing, the air first passes over the tempering coils, which in the heating season are supplied with steam. It then

passes through a spray chamber where the impurities are washed out and comes in contact with coils of 1-in. direct-expansion piping, 75 ft. of pipe per ton of air cooling being allowed.

From spray nozzles at the top of the chamber a constant stream of water is kept flowing over the coils, which prevents the formation of frost and maintains the coils at their highest efficiency. The humidity is controlled by the drop in temperature through the coils. At the lower temperature the dew point is exceeded and part of the moisture is condensed. It is removed as the air passes through the eliminator at the outlet end of the chamber. In passing through the distributing ducts to the rooms the temperature of the air is raised by the

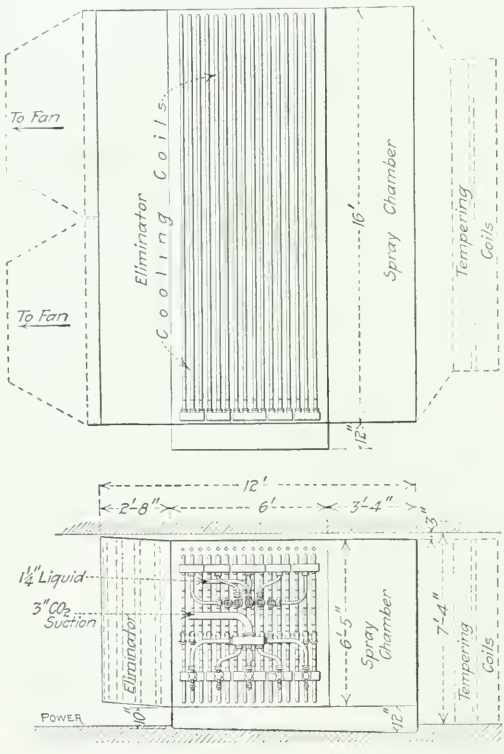


FIG. 2. AIR-COOLING CHAMBER

higher outside temperature. With the same amount of moisture the air will have a lower humidity at the higher temperature, so that by properly adjusting the drop and subsequent rise in temperature it is an easy matter to maintain the desired temperature and humidity in the rooms.

In each of the rooms to be cooled there is a series of registers at the ceiling and a second series at the floor. In the winter the air is introduced at the ceiling and drawn out at the floor, but in the summer months the circulation is reversed by means of reversing dampers in the ducts. The cold air enters at the floor and as it is heated rises to the outlets at the ceiling. For high rooms particularly this is the proper method, for if the air entered at the ceiling it would have lost most of its refrigerating effect before it reached the breathing line.

The system was laid out with capacity to change the air in the rooms every six minutes, but when the rooms are not fully occupied and the ventilating conditions are not severe at least half of the air can be recirculated and ventilation within the required limits still be maintained. For this purpose a recirculating duct has been provided. As the air drawn out of the rooms by the exhaust fan contains less moisture than outside air, less moisture has to be condensed in the cooling room and consequently less refrigeration is required. Regulation of the supply of cold air can be effected by a damper in the ducts or by the expansion valve at the entrance to the refrigerating coils.

The plant was erected under the supervision of John G. Lapham, Eastern manager of Kroeschell Brothers Ice Machine Co., of New York and Chicago, and to him we are responsible for much of the information contained in the article.

Watch Drain from Dehydrator

The dehydrator on an absorption machine is a very important part, and, yet, if not properly handled, it is a decided hindrance to the operation of the machine. Any irregularities in the operation of the dehydrator will bring about complicated conditions in the operation of the machine.

A combination angle and check valve is located in the drain pipe from the dehydrator to the generator. This valve is to prevent the gas from the generator taking a short cut through the dehydrator and also to let the drip from the dehydrator flow back to the generator. It is possible, when starting a machine, for the check in this valve to stick closed. This will let the dehydrator fill up with very rich aqua and overflow into the condenser; thence to the receiver and ice tanks. This condition robs the machine of aqua and gas, which is liable to cause "boiling over" and make the machine work badly. The temperature of this drain pipe should be closely watched by the operator.

G. A. ROBERTSON.

Louisville, Ky.

Congress of Refrigeration

The date for the Third International Congress of Refrigeration has been set for Sept. 17 to Oct. 1, 1913, inclusive. To carry out the exposition feature a separate organization, known as the International Refrigeration Exposition Association has been formed, and any information concerning space and other details may be obtained by addressing W. E. Skinner, general manager of the association, 819 Exchange Ave., Chicago. The International Amphitheater, 42nd and Halsted Sts., which has 75,000 sq.ft. of floor space has been secured, and as it is directly connected to 28 railway lines running into Chicago, there should be no difficulty in shipping exhibits. A great many of the engineering and manufacturers' associations will hold their annual or special meetings at the exposition, so that visitors may learn a great deal about the subject of refrigeration, as well as see its application in ice making, cold storage and other practical uses.

EDITORIALS

The Afflicted Middle West

Flood and flame in the Middle West, as has been noted in the daily press, have caused an appalling disaster. At this writing it is impossible to portray its horrors, nor do but scant justice to the always quick sympathy of the American people, who have opened their hearts and their purses with a readiness that makes us all proud of our country.

Galveston and San Francisco were local in their disasters when compared to this desolated region that is larger than some countries in Europe.

How heavily the disaster weighs upon the men in the operating field cannot now be learned. Their duty lies "below decks," and what sacrifices the engine and boiler-room forces have made may never come to light. It is theirs "to do and dare," and seldom does the public know of their heroism or their self-sacrifice.

To what extent the power plants, factories and office buildings in the afflicted cities have been wrecked or shut down is also unknown, but, however great the damage, there is some consolation in the knowledge that heat, light and power are among the first needs of this wasted territory and that the men in the operating field must of necessity soon be set at work.

This is a time when the engineer, trained to responsibility, will be leaned upon by those who would be wellnigh helpless without him. No one is better fitted to assume responsibility than he whose vocation daily, nay hourly, brings him face to face with danger; whose duty it is to protect the life and welfare of others, and whose calling has the prime requisites of skill, quick judgment and prompt action. Whatever public heed may be given to this engineer, he is absolutely necessary if public utilities are to perform their functions and comforts be provided.

⁂

A Remedy for Ill-Advised Legislation

Just now, when public complaint is so loud against the crowding of statute books with unnecessary and ill-advised laws, it is well that attention should be directed to one of the purposes of the technical societies and the useful work they are attempting.

As a case in point, it is announced by Charles Baskerville, chairman of the committee on occupational diseases in the chemical trades, appointed by the New York Section of the American Chemical Society, that the society stands ready to give the New York and New Jersey legislatures, and all manufacturers interested, the benefit of its services, and urges that they be utilized to the end that much unwise legislation and many commercial mistakes be prevented.

This is as it should be. No important step is taken by legislators and large industrial interests in most European countries without first seeking the approval of the society most fitted to pass upon the undertaking at issue.

In the United States there is an apparent inclination by legislative bodies and the industrial interests to ignore the societies. Why? It cannot be explained away by the assumption that our societies are not properly equipped to deal with any problem that may arise in their particular field of endeavor. These bodies are conspicuous both here and abroad for their good work, and in most cases are affiliated with the international organizations.

It is time that this matter be given the widest publicity, in order that the public may know that it has access to the services of the societies, and that they in turn gain the standing that should be theirs as sources of authority. It is not meant to give the impression that the public has a right to demand exhaustive investigations or ask purely consulting engineering involving personal sacrifice gratis, for "the laborer is worthy of his hire." These bodies can, and should be, however, consulted on all questions affecting the general welfare, both in the legislatures and in business.

When these conditions shall have been brought about we will have put a stop to much ignorant and pernicious legislation, prevented many costly business mistakes, and placed our societies on a plane where they will be much more useful and get public credit for that usefulness.

⁂

Poor Lighting in the Power Plant

Inadequate lighting in the power plant is the shallowest sort of false economy, yet many installations are very poorly illuminated. Any campaign for improved efficiency of operation which does not include a vigorous fight for first-class illumination misses an opportunity. There is no excuse for the failure to provide suitable lighting units now that the tungsten lamp with its efficiency of one and one-quarter watts per candlepower, even in the smaller sizes, is available.

Without proper light the provision of the best indicators, instruments and tools only partly meets the requirements of efficient operation. Even in a small plant electrical energy is cheap enough in these days to justify a liberal use of forty- or sixty-watt tungsten lamps above the machinery plane, and it is astounding how such an installation will improve conditions in a plant formerly lighted by ordinary sixteen-candlepower carbon incandescent lamps, whether singly or in small groups.

In most plants the machinery presents dark surfaces to the eye, and to facilitate inspection the volume of light must be relatively high. The use of white-enameled brickwork in the settings of boilers and of white marine or other durable paint on the walls in place of dark finishes are steps in the right direction. With the use of mechanical fuel-handling systems much of the dirt of the boiler room has been eliminated, but even the hand-fired establishment offers a good field for the use of special lighting. More care in providing suitable reflectors in front of gages and water columns, installing lamps so

that the light flux will be thrown upon bearings, gearing, starting boxes, fuse panels, scales and other auxiliary equipment, and in looking after regular cleaning of glassware will pay a high rate of interest on its cost.

A noteworthy improvement is that the firing aisles of some of the latest boiler rooms back up against large window spaces in the building walls, so that natural lighting and ventilation are secured with comparatively little trouble. Again, some of the best designing engineers are now preparing plans of station wiring in the same detail that pertain to the piping layouts, showing the size and location of every fixed lamp and switch in the establishment before the equipment goes into place. Detailed wiring diagrams of large buildings are long-established practice, but it is a new departure to devote an equal amount of care to power-house illumination plans.

To treat this important subject of station lighting from a fresh point of view is difficult, but the recurrence of faulty practice in this field warrants renewed reference to its defects. It is a question if lighting by lamps connected in parallel even in electric-railway plants is not better practice than series illumination, since the multiple installation permits cutting out individual lighting units in out-of-the-way corners, when they are not required, better than the series installation.

All too often the effectiveness of the lighting is hampered by the insufficient protection of the fixtures against oil and carbon dust. A more thorough study of the best heights for lamps in relation to existing installations of machinery is needed in many plants, and the preparation of a lighting survey in a poorly illuminated power house with recommendations for better arranged and selected equipment is one of the most useful tasks which the engineer can undertake if he is prepared to present his facts and conclusions to his superior with tact and sound judgment. Fortunately, many of these improvements can be had at extremely low cost.

Practical Studies of Depreciation

The accumulation of accurate data bearing upon power-plant depreciation is well worth the attention of operating engineers. There is scarcely another subject in which educated guesswork plays so large a part. Actual life records of individual equipment are literally worth their weight in gold at times when the owner of a plant wishes to sell it or raise money upon its performance and status, as when an electric-lighting or street-railway company appears before a state commission to obtain authority to float a bond or a stock issue. While such work may seem none of his concern, it is a fact that the operating engineer can often help his employer prepare a better case if he has made it a practice to keep life and depreciation data. It is not a work which will yield immediate results, but it is one which should be carried on as a sort of side line when the opportunity is favorable.

Judging from the way in which data are presented before public-utility commissions by power and lighting companies, here is a field where the operating engineer can make himself more useful if he is of a methodical mental turn. More and more these commissions are calling for specific data as to the life of all kinds of machinery, the amounts which must be expended upon it for repairs and the wear and tear which finally make it necessary to replace it with new equipment. Too often only approximate guesses are offered as to the life of apparatus, based upon the general opinions of executives more or less out of touch with the details of replacement and the multitude of little costs which amount to such surprising totals in the course of a few years. As a result the commission discounts the company's statements and exhibits, unless they can in a measure be checked, or else it accepts the estimate of the company and perhaps, through the latter's own inadequate notions as to its depreciation costs, does not authorize sufficient money to enable the property to be carried on in the best possible way financially, simply because the petitioner for the right to issue funded paper did not realize the extent of its depreciation. Even if an overestimate is presented, there may be an economic injustice perpetrated; but where data are submitted based on actual costs and life records, it would seem that a fairer solution of the problem might be attained.

To go about such a task the engineer should put down in a notebook the date of installation of every important piece of machinery in the plant, its first cost, where he can obtain it, and the dates and costs of all replacements and repairs in the nature of renewals affecting each machine unit under his charge. This is simple to do if it is begun at the right time and kept up as long as the plant keeps going. It may be necessary for the engineer to pass the maintenance and depreciation record book along to his successor; in fact, it is not likely that such a record will begin to have much real value until perhaps five or ten years after the plant is placed in operation, but the older it gets, the more useful it will become.

If such a practice as this were widely carried on, with the appreciative coöperation of engineers in charge of plants and their superiors, the whole industry would be enriched in a comparatively few years along lines which are at present largely subject to the roughest estimates, and to "blanket" allowances for depreciation which cannot be audited or checked as could specific figures taken from actual practice in the installation of new parts and the renewal of machines. Doubtless information of this kind is supposed to exist in many well managed companies, but as a matter of fact it is exceedingly scarce. There is room for pioneer work of a genuinely scientific character to be done in this important field by engineers who are ambitious to become something more than creatures of routine.

The extension of the principles and practices of commission regulation over the affairs of public-service companies is bringing out new phases of their costs almost every week, and the thoroughness with which evidence is prepared often means more to such companies at the hands of the regulating tribunal than the gains of many months in unit cost of production at the generating station or in improvements in the economy of transmission. Engineering work lies at the very foundation of just and efficient administration of such utilities, and the far-sighted operating engineer should realize this, even if there appears to be no present demand for his services in this apparently exalted field.

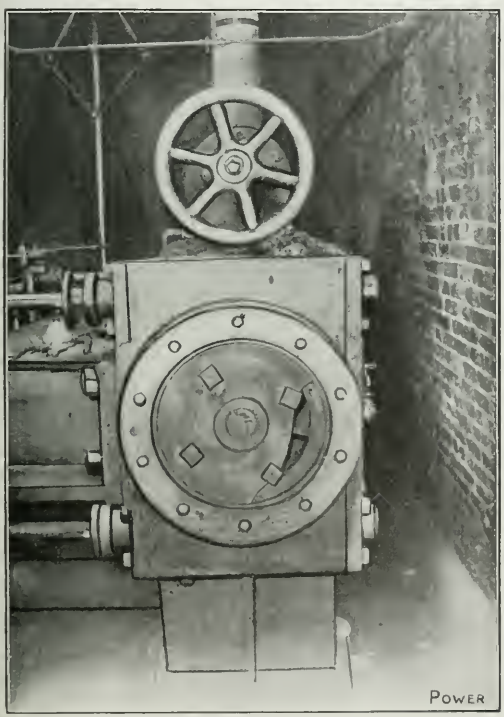
Those who have been following the study course will have a chance to test themselves with this week's review and rest. Next week the answers will be given and the week following the course on combustion will start.

READERS WITH SOMETHING TO SAY

Piston Rod Pulled out of Crosshead

On Wednesday, Jan. 15, an accident to the 16x48-in. engine at the J. C. Bennett estate, in West Lynn, Mass., shut the plant down until connections could be made with the local central station and motors installed to run the plant. The engine was built by Corliss & Nightingale in 1848, and its career is probably ended as repairs are not contemplated. The engine ran at 70 r.p.m. with a boiler pressure of 100 lb.

The direct cause of the accident was the separation of the piston rod from the crosshead, due to the threads



Fractured Piston Head

on the end of the rod and in the crosshead having worn from looseness and long continued play until the holding power of the threads was unequal to the strain to which they were subjected; the pull of the piston-rod nut at each taking up of the slack no doubt hastened the final separation.

A short time previous to the accident the engineer noticed play between the rod nut and crosshead. The engine was stopped and the nut drawn up tight against the crosshead, after which the engine was again started and brought up to speed. The engineer had barely completed opening the throttle and stepped to one side to note the effect of tightening the nut when the piston crashed into the cylinder head, shearing the studs, breaking the head into four pieces, and otherwise damaging the engine.

The illustration shows the piston in the position it was found after the accident, the broken follower plate, and also the position directly in front of the cylinder head which the operator was obliged to assume while manipulating the throttle. Remarks concerning the engineer's narrow escape from death or serious injury seem superfluous.

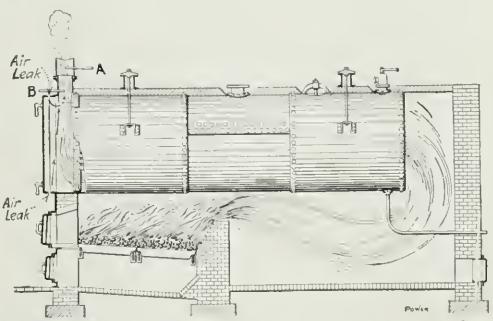
Charles F. Adams.

Lynn, Mass.

Taking Flue Gas Samples

In the analysis of flue gases as in everything else there is a right and wrong way to do it. The object of analyzing flue gases is usually to study combustion conditions and if the method of collecting the gas is correct and the analyses are properly made there can be no better way of determining these conditions.

Much depends on where the sample of gas is taken,



Showing Good and Bad Location of Intake for Gas Sampling

and the object of the analysis. If, for instance, the object is to keep close "tabs" on combustion conditions, as in running an efficiency test, gas analyses should be made every few minutes, particularly if burning bituminous coal. If, however, the object is to check up the general average of a boiler, plant or fireman, some good method of drawing out an average sample covering the entire watch and an analysis of one sample at the end of the watch would be sufficient, or a reliable CO_2 recorder could be used.

Recently I assisted in testing a horizontal return-tubular boiler burning bituminous coal. The test was on when I reached the boiler room. The gas was being drawn from the breeching at about the point *A* in the illustration. I had a hole drilled in the furnace front just above the front doors. These doors were like those

in most settings of this sort in that they did not close tightly, and, therefore, leaked much air, which, mixed with the gases, diluted them, and showed a comparatively low per cent. of CO_2. When the sample was taken out of the tube marked *B* in the illustration, the CO_2 was higher than when taken from the point *A*. Samples drawn from *A* analyzed about 8 per cent.; samples drawn from *B* about 14 per cent.

The object of this test was to determine the efficiency of a patented furnace, and much depended upon keeping the fire in good condition. As there is a definite relation between the percentage of CO_2 and the holes in the fire, I believe it is important to take samples every few minutes and analyze them right at the boiler, for the reason that changes in conditions occur rapidly. Once in this test a sample of gas showed 4 per cent. CO_2. We got the fireman to break up his fire, level it off, and a sample of the gas then taken showed 14 per cent. Between these two readings about three minutes elapsed. By the method used by the chemist on this job little would have been learned, for it took him five minutes to walk to the laboratory, and another ten minutes to analyze the sample, so that the shortest intervals between analyses would have been twenty minutes. In the meantime many changes might have taken place in the furnace.

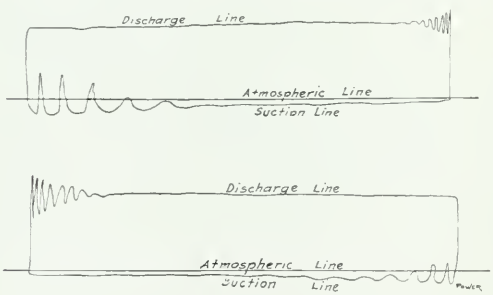
ALFRED FRANKLIN.

Cheltenham, Penn.

What Causes the Wavy Suction Lines?

The accompanying diagrams were taken from a double-acting, duplex pump of 5,000,000 gal. daily capacity, with a suction lift of approximately 10 ft., running at 30 r.p.m. and having a 30-in. stroke.

I would like to hear from some experienced pump man



WAVY SUCTION LINES

as to the causes of the wavy suction lines on the indicator diagrams.

J. F. REYNOLDS.

Phoenix, Ariz.

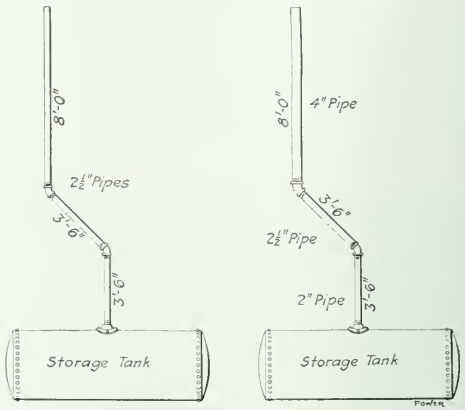
Oil Flow Problem for Discussion

Recently my attention was called to a plant using fuel oil in its furnaces. A storage tank was placed 15 ft. below the surface of the street, and had a 2½-in. pipe fitted as shown in Fig. 1.

The tank's supply of 1100 gal. was received from a common oil-delivery wagon through this 2½-in. pipe. A solid connection was made between the delivery wagon and the top of this pipe thereby providing all the head attainable, and then it took 45 min. for the 1100 gal. to flow into the storage tank.

The oil company demanded the reconstruction of the delivery pipe, and by reason of different obstructions, a straight pipe could not be used. As a result, the 8-ft. length of 2½-in. pipe was removed and one of the same length, 4 in. in diameter, fitted in its place, as shown in Fig. 2; the remaining 7 ft. of pipe was undisturbed.

With this arrangement, the oil was simply permitted



GOOD AND BAD CONNECTIONS TO OIL-STORAGE TANKS

to flow out of the delivery wagon into the top end of this 4-in. pipe. The oil in the wagon providing no head for the pipe connected with the storage tank, as no connection between it and the delivery wagon had been prepared, and with this alteration, the 1100 gal. is discharged into the storage tank in 18 min.

The question is, how does this alteration produce the accelerated flow of oil?

H. O. MCCARTHY.

Vancouver, B. C.

Trouble with Piston Rod Packing

Considerable trouble has been had with the packing of the piston rod at the water end of our pump. This is because there is no suitable packing in the plant and I had to make the best of what could be found. In spite of all that could be done, a large stream of water would leak past the packing at each stroke, and, running on the floor, was very undesirable.

Recently I decided to make a packing out of material that could be found, and proceeded as follows: After thoroughly cleaning, the stuffing-box, some lamp wick was doubled and twisted until it was thick enough to fill the space between the piston rod and walls of the box, stuffing in as much as it would hold. Then the gland was put in place and the wicking pressed in around the rod, which left room enough to insert a few rings of ring packing. This arrangement has given satisfaction for the past six months on a pump that is used for pumping hot water.

JOHN KNAB, JR.

Maspeth, N. Y.

QUESTIONS BEFORE THE HOUSE

Corliss versus Four-Valve Engines

Concerning the respective merits of Corliss and nonreleasing gear four-valve engines, I believe that before considering any of B. E. Donovan's questions, as given in the Sept. 24 issue, it is appropriate to state that in spite of the better steam economy of well designed Corliss engines, there are other considerations which often make high-speed, four-valve engines more economical to install and operate.

A direct-connected unit with a Corliss engine occupies fully 60 per cent. more floor space than one with a high-speed engine. If high-priced land must be purchased with borrowed money and foundations and buildings erected with money likewise obtained, a heavy fixed charge is created, which in nearly every case is sufficient to more than offset the superior economy shown by Corliss engines and as these charges usually run for long periods, it is advisable to start them as low as possible.

This is why the high-speed four-valve engine is often guaranteed to equal the Corliss in economy, in many situations where real economy does not call for low steam consumption.

Many builders freely guarantee a water rate of 24 lb. per horsepower-hour, but a proposal from the buyer to penalize them for nonperformance and give bonus for any improvements usually causes them to raise the figure to 27 lb., which is the average for four-valve, high-speed engines under good service conditions.

It is not necessary to increase the clearance volume in four-valve engine cylinders as compared to the Corliss, of the same diameter, but the use of like volumes, with shorter strokes results in higher percentages of clearance in the high-speed engine. Thus a volume which is 3 per cent. of the piston displacement with a 40-in. stroke, will be 6 per cent. if the stroke is 20 in. and the bore the same.

It has been customary to regard all clearance as a source of waste, but the uniflow engines seem to contradict this view, as they are notable for large clearances and low steam consumption. This indicates that not the volume, but the area of the wall surface of the clearance is the more important factor in the source of loss.

Perhaps a good method of comparing engines as to probable steam consumption would be one based on the total internal surfaces of the cylinders to which the steam is exposed in a unit of time, making correction by means of the ratio of diagram factors. For instance, assume a Corliss engine with 20x40-in. cylinder at 112 r.p.m. using 23 lb. of water per i.hp.-hr.; and a four-valve, high-speed engine with 20x20-in. cylinder at 225 r.p.m. and unknown steam consumption. Assume that the cylinder has 7 sq.ft. of clearance wall area, including the cylinder head and piston.

The barrel of the 40-in. stroke cylinder has an area of 17.453 sq.ft. This plus 7 sq.ft. gives the Corliss engine a total surface per stroke of 24.453 sq.ft. The barrel of the 20-in. stroke cylinder has an area of 8.726 sq.ft. This plus 7 sq.ft. gives the four-valve engine a total surface per stroke, of 15.726 sq.ft. As the four-valve engine makes two strokes for one of the Corliss engine, we must double the figure 15.726, making 31.452 sq.ft.

We find then that the four-valve engine presents 31.452 sq.ft. of cooling surface to the steam in the same unit of time during which the Corliss presents 24.453 sq.ft., and were it not for the wire drawing and lower diagram factor of the four valves, the ratio

$$\frac{31.452}{24.453} = 1.286$$

would be an index of the relative water consumption of the engines.

The lower diagram factor makes necessary a longer cutoff in the high-speed than in the Corliss engine to do equal work. This gives a higher terminal pressure and temperature in the four-valve engine and with the wire drawing tends to produce a more even range of temperature in the cylinder of the high-speed engine.

Assuming that the gain due to the reduction of the diagram factor is proportional to the reduction and using Mr. Donovan's figures 0.87 and 0.95 we get $\frac{0.87}{0.95} = 0.915$ as the correction factor, and the steam used by the four-valve engine will be

$$23 \times \frac{31.452}{24.453} \times \frac{0.87}{0.95} = 27 + lb.\ per\ i.hp.\text{-}hr.$$

This is an average figure for high-speed four-valve engines, in which high compression is used. It is to be noted that those using low compression are more economical but usually do not regulate well. It is not possible to make a showing of low-steam consumption, and still not do it, but it is often possible to make a good showing of commercial economy with relatively high-steam consumption.

The movements of the valves in both types are due to the load carried. The main differences are that the Corliss valves open more fully and close more rapidly than those actuated by nonreleasing gears.

The short connecting-rods of high-speed engines should not materially affect the mean effective pressure of the indicator diagram but they do produce fluctuations of crank effort, which are equalized by the flywheel if it is sufficiently heavy.

Wear in four-valve high-speed engines is more rapid than in Corliss engines, particularly in the valves, if of the Corliss type. A true Corliss valve is relatively very narrow, when compared with the bore of the valve chamber; hence its tendency to roll is not so great as is that of valves the faces of which embrace nearly half the circumference of the valve chamber. Such a valve even if only slightly worn will roll away from one of its ports, permitting leakage, while the true Corliss valve, being narrow, seats firmly over its single port practically sealing it. This is no doubt the reason why four-valve high-speed engines fall off in economy after comparative-

ly short periods of operation. For this reason those with flat admission valves are probably preferable to those with four semi-rotary valves.

The nonreleasing gear will wear rapidly if its bearings and pins are soft, as the alternately acute and obtuse angles assumed by the valve rods combined with inertia effects produce heavy stresses in the gear. The governor must be very stable, or the wear on its pins and bearings will be rapid and good regulation will not be maintained.

With high-speed four-valve engines it is hardly possible to make good on a guaranteed steam economy as good as the economy of Corliss engines if cylinder diameters and characteristics of design, aside from the valve-operating mechanism, are alike.

None of the foregoing should be taken as condemnatory to the four-valve high-speed engine, as it has a peculiar field of usefulness, which no Corliss engine can fill equally well.

CHARLES F. PRESCOTT.

Los Angeles, Calif.

In answer to B. E. Donovan's inquiry, I would say that one reason that the nonreleasing four-valve engine shows economies quite equal to the releasing or Corliss type is that the time interval between the incoming and outgoing steam is more rapid and does not effect as great a variation in temperature on the cylinder walls, piston and rod; also less condensation occurs, due to this cause.

There is no practical reason why the clearance space should be increased just because the piston nears the cylinder head a greater number of times per minute.

The valve-gears of Corliss engines have been improved to admit of noiseless operation at higher speeds and the frames built are more rigid to admit of higher speeds and greater steam pressures. High-speed governors give closer regulation, etc.

If an engine is run entirely without compression the space due to clearance would be filled from the exhaust to the steam-line pressure with live steam and this is a waste.

It does not require as large a cylinder in the higher speed nonreleasing type to get the same piston travel per minute or to get the same number of foot-pounds of work done per minute.

The makers of the nonreleasing type cannot make their guarantee unless they can back it up; besides the round corner at cutoff on the indicator diagram is about offset by the late release on the single-eccentric Corliss. Some nonreleasing-type engines run in an inclosed crank case with a splash-oiling system and some of them have a valve-gear partially submerged in oil and the gear is not under the strain of lifting the dashpots, which is quite severe on single-eccentric Corliss engines running at high speeds.

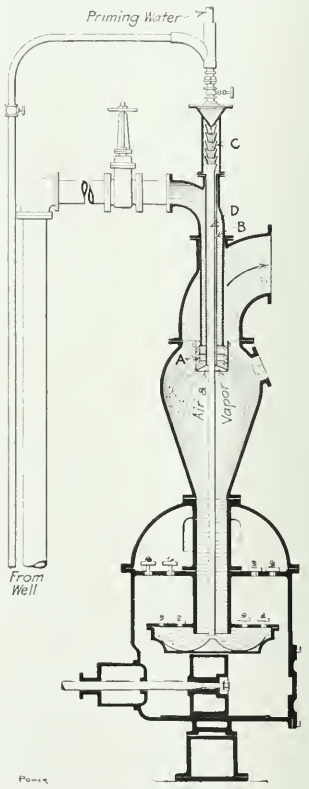
With no compensating adjustment in the cam levers the cutoff becomes increasingly later on the head end up to the half stroke as compared with the crank end, also the slower movement of the piston coupled with a slightly quicker opening of the steam valve has a tendency to hold the steam line up better on the crank end of the single-eccentric type Corliss engine.

Possibly the connecting-rod appears to be short on the nonreleasing type and yet, if compared with the length of its stroke, it would not in reality be so different. Many high-speed Corliss engines have a connecting-rod only two and a half times the length of the stroke.

Emmetsburg, Iowa. LEROY H. WHEAT.

Independent Air Pump for Condensers

In the Jan. 28 issue there appear extracts from a paper by William Weir, in which are described several European forms of pumps and nozzles for the separate extraction of air from condensers. In Fig. 1, page 134,



AIR REMOVED BY SMALL BAROMETRIC CONDENSER

is shown a "Dual" air pump, concerning which is said, "The wet pump A is situated below the steam cylinder, as this pump is the one which works under the maximum load. The dry pump B is driven by the beam and links in the usual way."

As, presumably, each plunger is single acting, is not the action of the pump as a whole very erratic? I would infer that the wet-pump plunger would plunge indeed when descending, and, judging from American practice, would soon bump and rattle itself to pieces unless steadied by a flywheel.

And will not the vacuum fluctuate considerably within the condenser as the result of the intermittent action of this slow-speed, single-acting, dry-air pump? I have often been told that the efficiency of an air pump de-

pends, in a large measure, on its ability to maintain a constant flow of air from the condenser, and for this reason, among others, a comparatively small double-acting pump, running at a fair speed, is to be preferred for a condenser auxiliary.

It will be observed that the dry-air pump discharges into the wet-air pump "at a point below the head valve." What advantage is derived from this novel arrangement? Is a partial vacuum formed in this space on the down-stroke of the bucket? Is the dry-air pump caused to discharge here to take advantage of it? I can see no other reason than a worthy attempt to overcome atmospheric pressure by dual compression, obtaining a two-stage effect.

But, assume an efficient air pump and one of proper size. When the plunger ascends, the condensate follows it, and, when at the end of its upward stroke, water should be touching both its top and bottom surfaces. How shall a vacuum be formed, especially if it is considered that the top sheet of water is subject to atmospheric pressure? If a vacuum is formed, might not the gaging of the amount be a reliable indication of the efficiency (or inefficiency) of the wet-air pump?

I am not in a position to test this; although we have a 14 and 32 by 21-in. "twin" as the auxiliary of a 1500-hp. engine. In this pump the head valve deck has been removed—in fact, it never was installed. For ten years the pump has given excellent service.

Are head valves a benefit to upright pumps; do they not retard the liberation of the air entrained in the water and make it necessary for the plunger to deal with this elusive element once more than is needed?

While on this subject, it may be pertinent to mention my own experience. Three years ago I helped a brother devise means for extracting air from a jet condenser. The main details are shown diagrammatically in the sketch.

It will be observed that the novel feature is the incorporation of a small barometric condenser as an auxiliary for the separate cooling and eliminating of the air. In the sketch, *A* is the cone distributor, which is secured by setscrews to the internal injection pipe and which closely hugs the air pipe *B*. The air collecting under the cone ascends pipe *B* and enters the chamber *C*, from which it is forcibly ejected by the descending jet of water and delivered, through the pipe *D*, in the form of cool aërated water into the suction chamber.

By increasing the mean effective pressure by one pound on the low-pressure piston, this improvement effects a saving of about $500 per year, with but a negligible loss in feed-water temperature at the primary heater, as a large economizer is in service.

R. O. Richards.

Framingham, Mass.

Indicator Diagrams from High Duty Pumping Engine

It seems surprising after Mr. Tucker's able comments on his own diagrams, page 318 of Power, that he should not be acquainted with a fundamental phenomenon of cross-compound engines.

During the first half of the high-pressure piston stroke, steam is exhausting into the receiver, without the existence of any outlet from it, unavoidably resulting in an increase of back pressure upon the high-pressure cylinder. But when the high-pressure piston is at mid stroke, admission to the low-pressure cylinder from the receiver occurs, creating an outlet from the receiver and thus decreasing the back pressure upon the high-pressure cylinder. The inevitable effect of these events upon a diagram taken from the high-pressure cylinder, is to produce the slight "hump" in the back-pressure line, which so concerns Mr. Tucker.

Lloyd W. Taylor.

Grinnell, Iowa.

Names for "Steam Stuff"

In the editorial columns, Mar. 11, I note the call for suggestions on a new word for "steam stuff." Why not call it "hydrol"? That is the new chemical name for water in its various forms. Steam is mono-hydrol, H_2O. Boiling water is (supposed to be) di-hydrol, $(H_2O)_2$. Cold water is a mixture of perhaps di-, tri- and tetra-hydrols, thus $(H_2O)_2$, $(H_2O)_3$, $(H_2O)_4$. Ice is a further polymer $[(H_2O)_n]x$.

Charles S. Palmer.

Newtonville, Mass.

A Suggestion

Oh, Power is in a great sweat,
Steam stuff, to rename, when it's wet,
The editor's stumped
Suggestions have slumped
"Hy-drox" may prove the best yet.

John Bailey.

Milwaukee, Wis.

Remedy for Lubricator Trouble

Referring to Mr. Rush's letter about a faulty lubricator, in Power, Feb. 18, I think the trouble is in the long and indirect connection between the sight-feed and main steam pipe. If Mr. Rush will connect the lubricator into the side of the steam pipe, doing away with the elbow, and at the same time bring the sight-feed as near to the pipe as possible, I think he will have no further trouble.

G. E. Madeley.

Brownsville, Tex.

If Mr. Rush will connect the nipple of the oil-delivery line from the lubricator to the side of the steam pipe, he will have no trouble with oil backing up in the glass.

He should be sure that the vertical 1-in. pipe on the side is at least 4 ft. higher than the oil well.

L. G. Borden.

Wharton, Tex.

If Mr. Rush will raise the lubricator so that the oil outlet will be on a level with or slightly above the steam main, the lubricator will work. At present there is no chance for a supply of water to reach the glass once the pipe outlet fills with oil.

James Noble

Toronto, Ont., Canada.

INQUIRIES OF GENERAL INTEREST

Connecting-Rod Angularity and Compression—How does the angularity of the connecting-rod affect the compression?

K. S. V.

The angularity of the connecting-rod has the effect of making the compression less on the crank end than on the head end because the crank-end compression occurs during a relatively smaller part of the stroke than the head-end compression.

Unequal Generator Voltages—When two alternating-current generators are connected to the same busbars and each carries 2000 kw. and uses the same amount of field current, what could account for unequal voltages on the two machines? (One is 6600 and the other 6400 volts.)

H. J. B.

Apparently the difference in voltage is due to the two machines not having the same excitation characteristics.

Earlier Cutoff—How can the cutoff be made earlier in a plain slide-valve engine without altering the port opening?

V. K. S.

Advancing the eccentric on the shaft would probably be the best way to make the cutoff earlier. If this is not feasible it may be possible to accomplish the desired result by adding lap to the steam ends of the valve or increasing the throw of the eccentric.

Fusible Plugs—What is the difference between an inside and an outside fusible plug?

S. C.

Fusible plugs for boilers may be entered in the tubes or shell of a boiler from either the fire side or the pressure side, or may be entered in the shells of the drums of a water-tube boiler in the same two ways. When entered from the pressure side they are called "inside fusible plugs" and when entered from the fire side "outside fusible plugs."

Position of Eccentric with Reversing Rocker—If a reversing rocker is used on an ordinary slide-valve engine will the eccentric occupy the same position as with a direct rocker?

S. K. V.

If a reversing rocker is used, the eccentric will not occupy the same position on the shaft as with a direct rocker, for with the latter the eccentric will be 90 deg. plus the angle of advance ahead of the crank while with a reversing rocker it will be 90 deg. less the angle of advance behind the crank.

Making a Barometer—In making a barometer, how can all the air be removed from the tube so as to get a correct reading?

F. P. B.

The mercury must be thoroughly boiled to expel air or other gases. After filling the barometer tube the mercury should be boiled in the tube to expel air bubbles that may adhere to the surface of the glass. For boiling out the air, the filled tube, open end up, can be heated directly by an alcohol lamp or the tube can be placed vertically in a bath of warm oil.

Deposit On Positive Wire—What is the cause of a deposit on the positive mains of an electric distribution system (light and power) in mines?

P. M. C.

Mine atmosphere contains sulphuric acid and often nitric as well. These two combining form aqua regia, a very powerful acid which attacks copper and forms a coating of oxide. It would seem that the deposit should be on the negative rather than the positive if electrolytic action has any part in it.

[If anyone can suggest an explanation for the reverse being true we should like to hear from them.—Editor].

"Double-eccentric" Corliss Engine—What is a "double-eccentric" on a Corliss engine? What is it for and how is it set?

E. P.

Strictly speaking, there is no such thing as a "double eccentric" on a Corliss engine. The name is frequently used to signify the presence of two eccentrics, i.e., one for the steam and one for the exhaust valves. Separate eccentrics are used to secure independent action of the steam and exhaust valves. The eccentrics are set at approximately 90 deg. with the crank, depending on the design and proportions of the valve-gear.

Pump Discharge Exceeding Piston Displacement—Can the amount of water actually delivered by a pump against a head exceed the piston displacement?

C. P. J.

This might be possible under certain conditions. When the rate of displacement by the piston is reduced without corresponding reduction in the velocity of the water through the suction pipe, the momentum of the water may be so great that, acting like a hydraulic ram, the velocity set up may be great enough to create sufficient pressure for some of the water to be delivered through the discharge valves. Any quantity thus discharged would be in excess of the actual piston displacement.

Edison Storage Battery—What are the materials used in the Edison storage battery?

A. B. D.

The positive element is nickel hydrate and the negative iron oxide. The electrolyte is a 21 per cent. solution of caustic potash containing a small amount of lithium hydrate. The nickel hydrate is loaded into perforated steel tubes in thin layers (about 300 layers per tube) and between each two layers is a thin layer of pure nickel to improve the electrical contact. The same function is served with the iron element by mixing with it, before loading, a little mercury oxide. The tubes are held by steel threads and the positive and negative elements are insulated from one another by rubber pins.

Fuel Oil—How many pounds of water will a pound of average fuel oil evaporate when fired under a large water-tube boiler? What is the weight of a cubic foot of fuel oil?

S. K. B.

California oil burned under water-tube boilers has been reported to evaporate the equivalent of 14.314 to 14.839 lb. of water from and at 212 deg. F. per pound of oil.

California, Texas and Java fuel oils have a specific gravity of about 0.92, while some oils from the eastern United States have a specific gravity of 0.84 to 0.87. The weight of a cubic foot of water (at 62 deg. F.) being 62.355 lb., the weight per cubic foot of any oil is found by multiplying 62.355 by its specific gravity. For example, California oil, or any other oil of 0.92 specific gravity, weighs

$$62.355 \times 0.92 = 57.36 \text{ lb. per cu.ft.}$$

Question of Boiler Capacity—Will a capacity of 520 hp. in water-tube boilers be sufficient to supply a vertical compound marine-type engine in a 400-kw. generating set?

G. F. B.

A boiler horsepower is usually based on an evaporation of 34½ lb. of water from and at 212 deg. F. (equivalent evaporation). This under the ordinary actual pressure corresponds to 30 lb. of water per hour, so the steam available from the boilers at normal rating would be

$$520 \times 30 = 15{,}600 \text{ lb.}$$

A compound condensing engine would use 20 to 22 lb. of steam per horsepower-hour, so that the boiler could supply an engine of this kind as large as

$$\frac{15{,}600}{22} = 709.09 \text{ hp.}$$

A compound noncondensing engine should not take over 26 lb. of steam per horsepower-hour, and therefore might be as large as

$$\frac{15{,}600}{26} = 600 \text{ hp.}$$

and not overtax the boiler.

As 400 kw. is equal to

$$\frac{400 \times 1000}{746} = 536 \text{ hp.}$$

the boiler capacity is ample even if the engine is to be operated noncondensing.

ENGINEERS' STUDY COURSE

Review of Mathematics with Test Questions

In this issue we conclude the lessons in mathematics by a review of previous lessons. In the lessons that follow, problems will be met with that require the use of mathematics, so the student is sure to receive plenty of practice in the subject.

To assist him in answering the following questions, the student is urged to make a brief review of all previous lessons. Answers to these questions will be given in next week's issue.

Following the review of mathematics will come several lessons in combustion and flue-gas analysis. After this, other subjects of importance to the engineer will be taken up.

(1) In the expression $\frac{1680}{144}$, which is the numerator and which the denominator?

(2) Express $\frac{22,043}{32}$ as a mixed number.

(3) Perform the following example by cancelation:

$$\frac{201 \times 740 \times 39 \times 16 \times 4}{8 \times 3 \times 4 \times 3 \times 37} =$$

(4) When addition and subtraction is indicated in an example, can the example be solved by cancelation?

The *least common denominator* of two or more fractions is the least number that will contain all the denominators of the fractions without a remainder.

To find the least common denominator, set all the denominators in a row and divide each that is so divisible by the smallest number (larger than 1) that will go into any of them without a remainder. Repeat the process until there are no remainders. Whenever a number or a remainder will not divide by the divisor then taken, bring the number down without dividing. Now multiply together all the divisors; the product will be the least common denominator.

Example: Find the least common denominator of $\frac{7}{18}$, $\frac{6}{9}$, $\frac{8}{12}$.

$$\begin{array}{r|l} 2) & 18 - 12 - 9 \\ 2) & 9 - 6 - 9 \\ 3) & 9 - 3 - 9 \\ 3) & 3 - 1 - 3 \\ \hline & 1 - 1 - 1 \end{array}$$

$2 \times 2 \times 3 \times 3 = 32 =$ least common denominator

When the value of the denominator is changed to that of the least common denominator, the value of the numerator must be correspondingly changed so that the value of the given fraction will not be changed.

Thus the least common denominator of $\frac{3}{4}$, $\frac{5}{8}$, $\frac{5}{16}$ is 16, but when the denominator 16 is used we must change the numerators as $\frac{3}{4} = \frac{12}{16}$; $\frac{5}{8} = \frac{10}{16}$; $\frac{5}{16} = \frac{5}{16}$.

Notice that we multiply the numerator by the same number that we would multiply the denominator by to get the least common denominator.

(5) Find the sum of $44\frac{3}{32} + 51\frac{6}{64} + 202 + 75\frac{1}{4}$.

(6) Subtract $229\frac{7}{16}$ from $242\frac{4}{16}$.

(7) Subtract $18\frac{3}{32}$ from 19.

(8) What is the product of $193\frac{1}{4} \times 225\frac{5}{8}$?

(9) State the rule for division of fractions.

(10) What decimal part of a foot is 9 in.?

(11) How many liters in a gallon?

(12) What part of an inch is a millimeter?

(13) One B.t.u. equals 0.252 large calories or 252 small calories; what is the calorific value (large calories) of coal containing 13,500 B.t.u. per lb.?

(14) Has the volume of a barrel ever been definitely standardized?

(15) What is 212 deg. F. on the Centigrade scale?

(16) The listed price of a steam trap is $30 with "40 and 10 off," what is the actual price of the trap?

(17) How many pounds of combustible in a ton (2000 lb.) of coal containing 12 per cent. ash?

(18) The formulas for ratio are

$$Ratio = \frac{antecedent}{consequent}; consequent = \frac{antecedent}{ratio};$$

$$antecedent = consequent \times ratio$$

What is the ratio of heating surface to grate surface in a boiler with a grate 7x9 ft. and with 950 sq.ft. of heating surface?

(19) What is the inverse ratio of 20:4?

(20) A pump discharging 220 gal. per min. fills a tank in 3 hr. How long will it take to fill the tank if it delivers 400 gal. per min.?

(21) What is the square of 2243_4?

(22) What number multiplied once by itself will produce 789?

(23) A steel shaft is to run at 80 r.p.m., and is required to transmit 28 hp.; according to the D. K. Clark rule (see POWER, Jan. 7, 1913, page 32), what size shaft should be used?

(24) Solve by logarithms:

(a) 33x3;

(b) Find the log of 31.428;

(c) Of what number is 4.4980071 the log?

(d) Find the log of 31,444.73;

(e) Of what number is 4.4931343 the log?

(f) What is the value of $642^{\frac{1}{2}}$?

In logarithmic tables, such as given in Kent's "Mechanical Engineers Pocket-Book," always use as the first two figures of the mantissa those given with the only complete mantissa (six places) contained in the same section of the table (boxed in with rules) that contains the last four figures of the mantissa. For example, take the log of 1113 (page 133, 7th edition; page 140, 8th edition). The mantissa will be 150112.

(25) To reduce the actual evaporation to an equivalent evaporation from and at 212 deg. F., the following formula is used:

$$W' = \frac{W(H - t + 32)}{970.4}$$

in which

H' = Equivalent evaporation from and at 212 deg.;
W = Actual evaporation;
H = Total heat of steam above 32 deg. F. at the pressure at which the water was evaporated;
t = Temperature of the feed water entering the boiler;
970.4 = Latent heat of evaporation.

To find the factor of evaporation use this formula

$$Factor = \left(\frac{H - t + 32}{970.4}\right)$$

In connection with these two formulas read the article "Factor of Evaporation," in the Mar. 11 issue, page 334.

Approximate the evaporation in your plant and apply the formulas for practice. Also turn back to page 276 of the Feb. 5 issue and work examples in safety-valve areas and commercial sizes by using the Massachusetts formula.

(26) How many degrees in $\frac{3}{4}$ of a circle?

Given the area of an equilateral triangle to find the length of a side.

An equilateral triangle being one, all of whose sides are equal, its altitude would divide the triangle into two right triangles.

Let

a = Altitude;
b = Base = Length of each side;
A = Area.

By the relations of the sides of a right triangle

$$b^2 = \left(\frac{b}{2}\right)^2 + a^2$$

or

$$a^2 = b^2 - \left(\frac{b}{2}\right)^2 = b^2 - \frac{b^2}{4} = \frac{4\,b^2 - b^2}{4} = \frac{3\,b^2}{4}$$

$$a = \sqrt{\frac{3\,b^2}{4}} = \sqrt{3}\left(\frac{b}{2}\right) = \frac{\sqrt{3}}{2} \times b$$

Since

$$\frac{\sqrt{3}}{2} = 0.866$$

$$a = 0.866\ b$$

But the area of any triangle is equal to half the product of the base by the altitude. Then the area of the equilateral triangle is

$$A = \tfrac{1}{2}\ (b \times a)$$

Substituting for a

$$A = \tfrac{1}{2}\ (b \times 0.866\ b) = \frac{0.866}{2}\ b^2 = 0.433\ b^2$$

then

$$b^2 = \frac{A}{0.433}$$

and

$$b = \sqrt{\frac{A}{0.433}}$$

which gives the formula for finding the side of an equilateral triangle when the area is given.

(27) What is the length of a side of an equilateral triangle having an area of 21.217 sq.in.?

(28) An inclined plane forms a triangle with the ground, the base measures 1762 ft., and the vertical distance between the ground and the elevated end of the plane is 662.5 ft. How long is the plane?

(29) If one gallon of paint will cover 42 sq.ft. of iron surface with three coats, how many gallons are necessary to paint a steel stack 60 ft. high, 6 ft. in diameter.

(30) What is meant by "mean circumference?"

(31) State the formula for finding the volume of a frustum of a pyramid or cone.

(32) Approximately, how many tons (2240 lb.) of pea coal will be contained in a bin $60\frac{5}{16}$ ft. long, $25\frac{7}{8}$ ft. high, and $31\frac{9}{16}$ ft. wide? One long ton (2240 lb.) of pea coal occupies 36.7 cu.ft.

(33) The solid cast-iron ball on a crane tackle chain is 11 in. in diameter. How much does it weigh, cast iron weighing 0.26 lb. per cu.in.?

Answers to Problems, Mar. 25 Issue

(1) $413.45.

(2) 1220.137 gal.

High-Speed Engine Wrecked

By T. K. Lee

An accident to a 175-hp. high-speed engine at the electric-light plant, Benson, Minn., recently wrecked the engine. It was a compound, with 12 and 18 by 14-in. cylinder, of the center-crank type, directly connected to a 100-kw. generator and running at 240 r.p.m. at the time of the accident.

This unit was installed eight years ago and was used

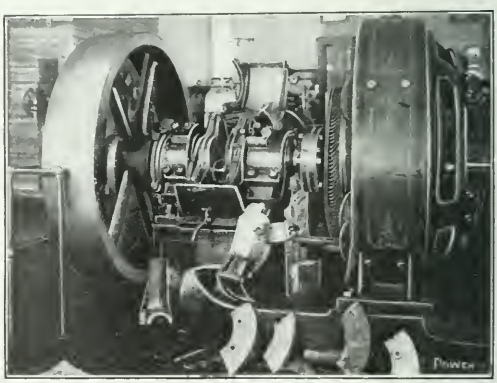


Fig. 1. Crank End of Engine

only for the peak evening load. Although the engine never gave any trouble, it was run only when the heavy load was on, because it was not economical in steam consumption. The engine had been running smoothly as ever, when the engineer, who had just come in from the boiler room, heard a sharp knock and the engine went to pieces.

The cylinder head and piston of the high-pressure cylinder was blown through the window, taking part of the wall with it and landed 50 ft. outside. The heavy counterweights on the crankshaft broke off and were thrown against the wall with great force, just missing the generator of the No. 2 unit.

The real cause of the accident was the breaking of one of the bolts holding the crank box together; a flaw was

plainly shown in this bolt. The other bolt held for some time, and was considerably bent before breaking.

When these bolts broke the connecting-rod dropped and the crankpin struck it with enough force to break it and send the piston against the head, shearing the studs and knocking out the cylinder head. In Fig. 1 is shown the crank end of the engine, the two counterweights which were broken and part of the broken connecting-rod. Fig.

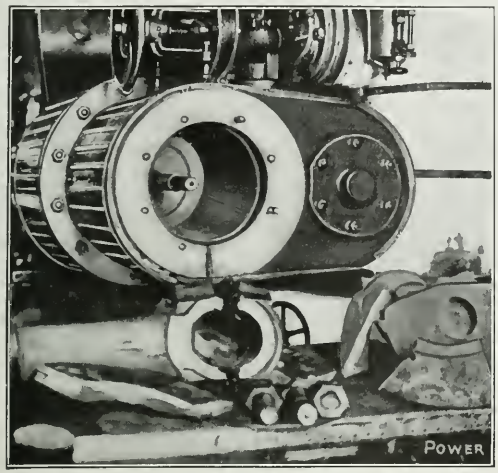


FIG. 2. HEAD END OF ENGINE

2 shows the head end of the engine with the head and piston knocked out. The stud bolts, 5/8 in. in diameter and spaced 5½ in. apart, were constructed of poor material.

Ocean Liner's Fuel Cost

The coal bill of a big trans-Atlantic liner is sufficiently great under ordinary circumstances, but when strike conditions prevail, with consequent high prices, the sum paid for sufficient fuel for a single voyage may amount almost to a small fortune.

The White Star liner "Olympic" for her last trip to this country was compelled to pay $5 per ton for her bunker coal, and had difficulty in securing enough to supply her needs at even this price. Her total expense for coal alone upon this voyage was $25,000.

Upon this trip the vessel carried 1586 passengers of all classes, and the expense for fuel for each passenger amounted in round numbers to $15.70. As the voyage was completed in 5 days, 18 hours and 46 min., the coal bill amounted to slightly over $3 per minute.

In reckoning fuel costs, all figures should be regarded as relative. Because one steamer burns a greater weight or value of coal than another, does not necessarily mean that her freight cost per ton-mile is any higher. It is probable that other vessels plying between the same ports at about the same time as the "Olympic" were compelled to pay equal rates per ton in order to fill their bunkers. It is doubtful, however, if any other steamer paid such an enormous sum for fuel enough for a single voyage.
Coal Age.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

There is a scheme on foot up at Niagara Falls, N. Y., to develop hydro-electric power from the outflow of that city's trunk sewers. Phew! Why not let well enough alone? Just when things seem to be flowing smoothly, some gink always wants to stir things up. We don't favor the water-power "possibilities" in the average sewer.

A college professor has written a book entitled "English for Engineers" which its reviewer recommends "to engineers who desire a little strengthening of their English." We fail to see its need. Some of the strongest English we ever heard in our young life came from engineers. While the vocabulary may have had its limitations, the strength would never be questioned for a moment.

A careful study of old man Webster's tome of definitions would often convince bitter disputants that they really think alike.—"The Woodworker."

The trouble with the majority of these bitter disputants is that they too often agree with the man who would not buy a dictionary because every time he looked in it, the dum book was wrong!

My word! It must be jolly rippin', old top, to be grate maker to a king. Where the additional prestige comes in, we know not, but when the London "Electrical Review" makes this solemn proclamation, it must mean something:

"Makers to His Majesty—The Carron Co. has been appointed grate makers to H. M. the King. The Carron works have been visited on many occasions by Crown heads of Europe, including Czar Nicholas I of Russia, Prince Leopold Maximilian of Austria, and by King Edward VII, when Prince of Wales.

No longer should we wonder at the man in Holy Writ who sold his birthright for a mess of pottage, or at the individual who told us to stop his paper as he knew "as much as Power." Give ear to this:

> WILL EXCHANGE a one-hundred-dollar engineering course for a motor-cycle in good condition. Address R. P. M., Box 123, Boston, Mass.

If "the pen is mightier than the sword," the pen has committed hari-kari in a mighty funny item in a Boston daily. It says that "the superheated locomotive is so called because the water in the tank is heated in order that it may be all ready to steam when it goes into the boiler." Well, I'll be gormed!

"THE EVIL OF POWER"

A reader in New Hampshire sent us this sketch, and said it was a joke we married men will appreciate. We do. We

are glad to state that our Lovey is not this kind of a lady but pained to learn that POWER has ever busted apart an apparently once loving couple. Have a care, Hen Jones; "hell hath no fury like a woman scorned"" You win Lovey's trusting, tender heart, and then you neglect her for a literary career (There's lots more we might say about Lovey, but we're afraid we'd rouse your jealousy Henry)

Modern Condensing Systems

SYNOPSIS—Relative advantages of surface and jet condensers and a comparison of reciprocating and rotary pumps, special attention being given to Westinghouse-Leblanc designs.

In a paper read before The Institution of Mechanical Engineers, A. E. Leigh Scanes presented an interesting discussion on the development in condensing systems which has taken place during recent years. He considered briefly surface and jet condensers and gave considerable space to air pumps, dealing, particularly, with the Westinghouse-Leblanc dry-air pumps. Circulating

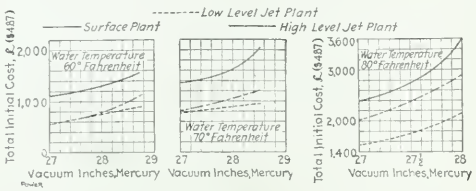


FIG. 1. COMPARATIVE INITIAL COSTS OF VARIOUS TYPES OF CONDENSER

pumps, extraction pumps and vacuum traps were also briefly treated.

In the paper surface condensers were divided into two classes, those in which the cooling water passes through the tubes and those in which the steam is condensed in the tubes by a small quantity of water flowing over their exterior. The jet condensers were divided into high level or barometric, low level, and ejector types. As a guide in choosing a plant, the series of curves shown in Figs. 1 and 2 were presented. Fig. 1 compares the initial cost of the various types and Fig. 2 the operating cost. In each diagram 40,000 lb. of steam per hour and a barometer of 30 in. were used as a basis. In Fig. 1 allowance was made for the original cost of the condensers, cooling

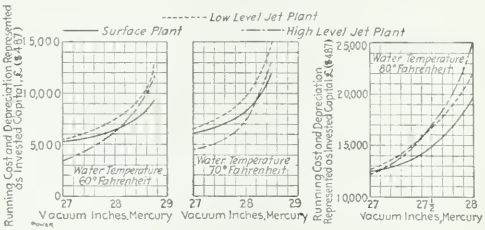


FIG. 2. COMPARISON OF RUNNING COSTS AT ½d. (1c.) PER UNIT AND DEPRECIATION CAPITALIZED AT 5 PER CENT.

towers when necessary, and foundations. In Fig. 2, depreciation at 12 per cent. per annum and a running cost of ½ pence (one cent in American money) per unit have been capitalized at 5 per cent.

SURFACE CONDENSERS

In the earlier types of surface condenser, it was stated that a low rate of heat transmission was usual, about 350 B.t.u. per sq.ft. of surface per degree Fahrenheit mean temperature difference, this rate giving a condensation of 5 or 6 lb. per sq.ft. per hr. for moderate vacua and water temperatures.

From the viewpoint of reliability, large surfaces have been preferred, since they are supposed to require less attention and cleaning to maintain a high vacuum. This may be true with moderately clean water, but marine practice has shown that small surfaces are best for reducing the formation of scale, owing to the increased water velocity. Furthermore, this increase of velocity through the tubes also increases the rate of heat transmission from the metal to the cooling fluids. In this connection, Fig. 3 shows experimental results obtained by various authorities.

The author refers briefly to the drop of vacuum caused

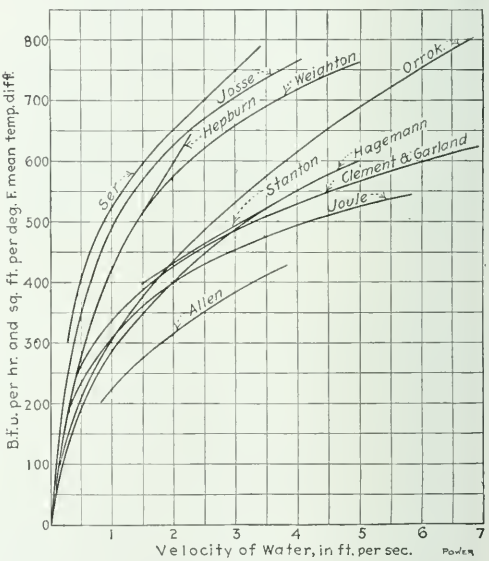


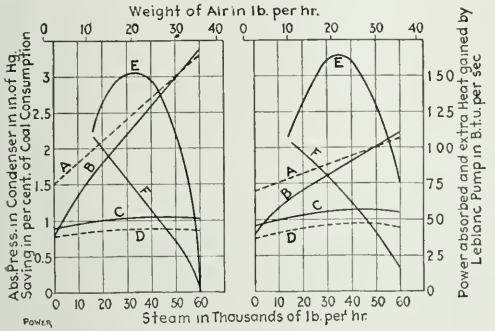
FIG. 3. HEAT TRANSMISSION FROM STEAM TO WATER IN SURFACE CONDENSERS

by the tubes throttling the flow of steam, and the efforts made to overcome this by keeping a constant steam velocity. This was accomplished by placing the tubes farther apart near the steam inlet, making the condenser shell heart shaped to offer a large surface at the top, gradually decreasing to the air outlet, and running passages among the tubes. The first and last methods have been adopted by the British Westinghouse Electric & Manufacturing Co., and some illustrations of their condenser were presented with test data to show the efficiency of operation. Air logging of the bottom tubes and vacuum efficiency were also given brief mention.

JET CONDENSERS

This type of condenser may be used when the supply of cold water available either from natural sources or from a cooling system is suitable for boiler-feed purposes. Even when this is not the case, but the water is of a qual-

ity which would rapidly scale or pit the tubes of a surface plant, jet plants can often be used in conjunction with a purifier for feed purposes. The power absorbed by the pump is usually higher than for a surface plant, although the actual water quantity required is considerably less, the excess power being due to the water being extracted from the condenser body against the vacuum head (which is approximately 32 ft.) in addition to any external pressure. The air pump must also be larger to deal with the air liberated from the water, usually not less than 2 per cent. of the volume at atmospheric pressure. Reference was made to the earlier forms of jet condensers, and a


Weight of Air in lb. per hr.
Abs. Press. in Condenser in in. of Hg.
Saving in per cent. of Coal Consumption
Power absorbed and extra Heat gained by Leblanc Pump in B.t.u. per sec
Steam in Thousands of lb. per hr.
A
B
C
D
E
F
Power

FIGS. 4 AND 5. RELATIVE OPERATING DATA OF LEBLANC AND RECIPROCATING PUMPS

A Absolute pressure in condenser with wet piston pump.
B Absolute pressure in condenser with Leblanc pump.
C Power absorbed by Leblanc pump.
D Power absorbed by wet piston pump.
E Net gain in B.t.u. obtained with Leblanc pump.
F Percentage of coal consumption saved with Leblanc pump.

description was given of the Westinghouse-Leblanc multiple-jet condenser.

Barometric jet condensers are similar to the low-level type with the exception that the hot water and condensed steam are removed by means of a barometric leg instead of an extraction pump. The disadvantages consist of greater expense, more room occupied and loss of vacuum between the condenser and main unit, due to the abnormal length of the exhaust pipe. This loss may vary between ¼ and 1 in. of mercury. In the majority of cases, a low-level jet is to be preferred, the only condition where a barometric plant is advisable is when the cooling water is at a level which does not necessitate an injection pump.

For very small steam quantities, ejector condensers are employed. A diagram of one of the best forms of the older designs was shown in the paper and also a diagram locating the critical point. The Westinghouse-Leblanc simple jet condenser was illustrated.

Air Pumps

Considerable space was given to air pumps, and, as with the other apparatus, most of it was devoted to the Westinghouse product. Brief mention was made of the Parsons vacuum augmenter, reciprocating pumps, the rotary spray air pump, and a simple water-ejector type of air pump, but most of the space under this division of the paper was devoted to the Westinghouse-Leblanc dry-air pump. Its advantages were pointed out and comparisons made with other types of pump. Diagrams showing the comparative floor space occupied by Leblanc pumps and reciprocating pumps were given, and also an illustration, showing the new method of operating the pump in connection with a tank in which the water level is above the suction. The advantage of this arrangement over the old method of drawing the water from a seal-well below the axis of the pump is apparent. Should the vacuum fail for any reason, the pump remains primed, and on the leakage being topped it picks up again without attention.

Figs. 4 and 5 show graphically the relative power absorbed by a Leblanc rotary air pump, including rotary hotwell pump, delivering to 10 ft. external head, compared with a reciprocating wet-air pump of good design. In Fig. 4 full load has been taken at 27 in. vacuum, and in Fig. 5 at 28 in. vacuum. The power has been given in B.t.u. for the sake of simplicity, an overall efficiency of 20 per cent. being assumed. The other curves give the respective total absolute pressures in the condenser, the total heat returned by the rotary pump in the hotwell in excess of that returned by the piston pump, the net gain in B.t.u. and the overall gain in coal consumption, assuming that live steam at 100 per cent. efficiency be used to raise the hotwell temperature before entering the economizer, in the case of the piston pump.

In calculating the net gain and B.t.u., allowance has been made below full load on the condenser for the decreased steam consumption for equal power outputs, due to the higher vacuum maintained by the Leblanc pump.

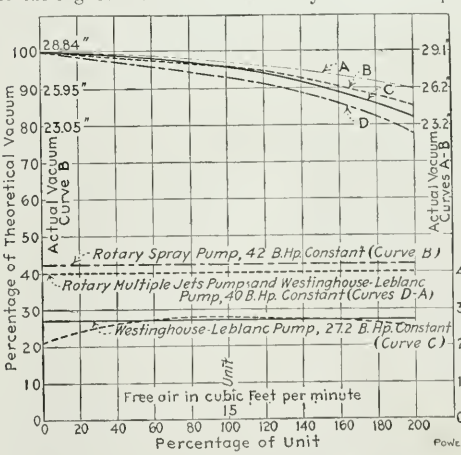

28.84"
25.95"
23.05"
Actual Vacuum Curve B
Actual Vacuum Curves A-B
Percentage of Theoretical Vacuum
Brake Horsepower
Rotary Spray Pump, 42 B.Hp. Constant (Curve B)
Rotary Multiple Jets Pump and Westinghouse-Leblanc Pump, 40 B.Hp. Constant (Curves D-A)
Westinghouse-Leblanc Pump, 27.2 B.Hp. Constant (Curve C)
Unit
Free air in cubic Feet per minute
Percentage of Unit
Power

FIG. 6. TEST RESULTS FROM ROTARY PUMPS

Barometer during test of rotary spray pump 29.47 in. hg. Temperature of water used 64 deg. F., corresponding to a water vapor tension of 0.63 in hg. Theoretical vacuum 28.84 in.

Barometer during test of Westinghouse-Leblanc pump 29.78 in.

Temperature of water used 68 deg. F., corresponding to a water vapor tension of 0.68 in hg. Theoretical vacuum 29.1 in.

Curve A—Vacuum obtained with Westinghouse-Leblanc pump absorbing 40 b.hp.

Curve B—Vacuum obtained with rotary spray pump absorbing 42 b.hp.

Curve C—Vacuum obtained with Westinghouse-Leblanc pump absorbing 27.2 b.hp.

Curve D—Vacuum obtained with rotary multiple-jet pump absorbing 40 b.hp.

This decrease has been taken as 5 per cent. mean between 27 and 28 in. vacuum, and 6 per cent. between 28 and 29 in. vacuum. In Fig. 6 curve *C* shows a test on a Leblanc pump superimposed on the test of a rotary spray pump. The pumps are of approximately the same capacity, and it

will be seen that the power taken by the former is considerably less than by a rotary pump.

Circulating Pumps

In the section devoted to circulating pumps, reference was made to the tendency of purchasers to look only at the initial outlay and overlook running efficiency and reliability. In choosing a centrifugal pump it must be remembered that the speed at which the pump is to work is fixed for a maximum efficiency. The first point to settle then is the most suitable speed for all conditions of service. The next point is to consider if it is advisable to run this pump from the same motor or engine which is to drive the air pump. With reciprocating air pumps this is usually done with the help of gearing, but this arrangement is not usually liked on account of the noise, and the best alternative is a rotary air pump which, when possible, should be run at the same speed as the circulating pump.

When the cooling water has to be lifted against a low head, however, the circulating pump must be run at a relatively slow speed, which would naturally detract from the efficiency of the air pump, and in this case separate motors would be advisable. When a cooling tower must be used, and the head against the circulating pump is 30 ft. or more a high speed can be utilized and all the pumps direct coupled. Even with the high head the efficiency of the water pump will be relatively low—about 65 per cent. for a speed of 2500 r.p.m., but the advantages of a self-contained unit, which does not depend on the main plant for power, usually more than compensates for this and the additional initial outlay involved.

Extraction pumps for use with surface condensers were given a paragraph, and similar space was given to vacuum traps for removing condensation from exhaust lines when there is a fall in the exhaust pipe toward the engine.

The extended discussion following the paper was largely devoted to the operation of the Leblanc pump, its early faults and its development. Capt. H. D. Sankey thought that the Leblanc pump was specially suitable when a good vacuum was required, as in the case of turbines. With reciprocating engines where a vacuum of 26 to 27 in. sufficed, the reciprocating pump probably had the advantage.

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Progress of the 1915 Exposition

While the construction of the Panama-Pacific International Exposition, to be held in San Francisco in 1915, is breaking all records in its progress, arrangements are being made for innumerable conventions and conferences to meet at the Exposition in 1915.

Every trade and profession in the world will be represented in some form in the exhibit section and it is intended that similarly, every trade and profession shall be represented in convocation. In planning the Exposition, such ample provision has been made for the accommodation of conferences, that already hundreds of applications have been received from all parts of the world for dates to hold gatherings and festivals. The most notable of the conferences already arranged for are the International Peace Conference, Conventions of the Inter-Parliamentary Union, the Institute of International Law and the Pan-American Congress. Other conferences in the interest of commerce, public health, art and music are being arranged.

All building will be fully completed eight months before the opening of the Exposition. By August, 1914, many of the exhibits will have been installed and the grounds terraced and planted with trees and flowers. Every detail of the Exposition will be perfected at least two months before the opening date.

The Flood

No disaster since the Galveston flood and the San Francisco earthquake can be compared to that which the daily press has depicted the past two weeks of the flood in the Middle West. Of the extent of the loss of human life and the suffering and destitution of the survivors no accurate estimate can be made at this writing (Mar. 31). One day it is stated that the dead will number between 500 and 1000, and the next it is said that "fire or the flood has claimed thousands of the missing." This account is taken from the news reports as they were published and its statements must be regarded with more or less reservation.

Of the states most afflicted, Ohio, Indiana, Pennsylvania and West Virginia, Ohio has suffered the most in this calamity. Dayton, Cleveland, Columbus, Zanesville, Steubenville, Tiffin and Delaware, where the greatest damage occurred, are under martial law, and food, clothing and medical attendance are being dispensed systematically and effectively.

The cities' water-works and sewerage systems are being rapidly restored to operating conditions where possible, to prevent fever. Some of the systems only need repairing of the equipment.

Many of the factories in these cities have been either entirely demolished or the machinery and power plants wrecked beyond repair. In several cities some time must elapse before the lighting and power plants and the gas service can be restored.

In Indiana, Peru, West Indianapolis, Fort Wayne, Lafayette, Logansport, Terre Haute, Kokomo, Martinsville, Shelbyville, Connorsville and many other smaller towns were devastated.

Most of the Dayton office buildings are intact, and need only to be cleared of mud and débris and the power plants freed of water.

The plant of the Dayton Light, Gas & Coke Co. was destroyed by fire. The electric light and gas plants are said to be uninjured. Later Dayton dispatches say that: 'The first call to work was issued today (Mar. 29) and by Monday morning the reassuring notes of factory whistles will relieve distraught minds of men and women who are still nerve-racked and ill from an experience that has been little less terrifying than Galveston's."

This call comes from the Dayton Engineering Laboratories Co., the youngest of the city's big industrials. Its million-dollar plant, manufacturing electrical starting apparatus for automobiles and employing 1100 men, was in the center of the worst flooded district, East First and Foundry Sts. Seventeen feet of water submerged the concrete building to within 18 in. of its second floor.

Many of the large manufacturing plants and shops have been forced to close down owing to the lack of transportation facilities, thus making an additional hardship on hundreds of employees.

The power plant of the Dougherty Co. and the dam in the Black River, which supplied power for lighting Elyria, Ohio, were destroyed by high water late Tuesday afternoon, Mar. 25. The water from the dam swept away the power house and a 70-ft. span stone arch bridge connecting the two halves of the city. The loss is estimated at over $70,000.

At Cleveland the unprecedentedly high water in the Cuyahoga River flooded the basement of the Canal Road plant of the Cleveland Electric Illuminating Co., and partially shut it down. Street lamps in the business section went dark and a number of the larger stores and business places were only partially supplied with light at night.

At Mansfield, Bucyrus and Ashland, Ohio, the municipal lighting plants have been shut down by high water.

The property loss in Ohio alone will probably reach $300,000,000.

As this paper goes to press it is reported that the Mississippi River is rising, and there are fears of great property loss, the flood having already spread over large areas in Missouri. The loss of life will undoubtedly be very small, if any, as the inhabitants have been warned in time to flee to the hills.

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Annual Dinner of New York City N. A. S. E.

On Thursday evening, Mar. 27, the annual dinner of the ten combined associations of Manhattan and the Bronx, National Association of Stationary Engineers, took place at the Broadway Central Hotel. The dinner was highly enjoyed by the 350 members and guests, and much deserved credit is due the banquet committee, Samuel I. Schaff, Fred G. Jolley,

Harry J. Marks, William M. Logan and Frederick Felderman.

Robert Johnson, as toastmaster, introduced as the speakers, Past President Edward H. Kearney, Vice-President James R. Coe, the Hon. William S. Bennett and J. D. Taylor, and Chairman Joseph F. Carney, of the National Board of Trustees, made the address of welcome.

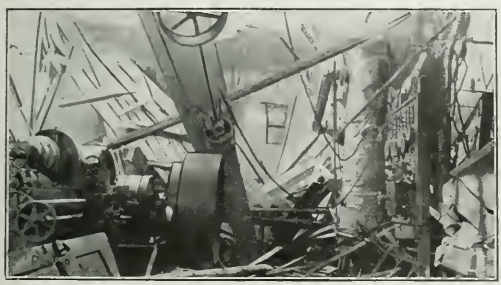
The entertainment features included a broadside from that strong battery of wit, talent and humor, Herbert Self, baritone; Jack Armour, humorist; M. J. O'Connell, tenor; Joe McKenna, comedian, and Billy Murray, of phonograph fame.

❖

Town Water Tank Burst

On the night of Mar. 10 the water-supply tank of the city water works at Ohio, Ill., burst and wrecked the electric light plant and pumping station, which were located almost beneath the tower.

The 50,000-gal. capacity tank was made of 3-in. staves and had been in use about 18 yr. Some of the hoops were badly rusted, which was the cause of the disaster. Although one side of the tank fell on the boiler room, taking the smokestack and steam pipes with it, and filling the boiler room with cold water, practically no damage was done to the boilers, which were under pressure at the time.



Wrecked Plant and Station at Ohio, Ill.

As this plant was the city's only source of water supply, something had to be done quickly; so a traction engine was brought in from the country and used to furnish steam for one of the pumps which was not badly damaged. This worked so well that it was decided to try to run one of the generators in the same way. A larger traction engine was run up as closely as possible to the other side of the building and the steam piped to a 10x12-in. engine, which also had escaped being wrecked. In this way the town is being supplied with lights and water until the plant can be put in shape again and a new tank erected. The service was only interrupted for about 6 hr.

❖

Boiler Inspector Bill for New Jersey

Assemblyman Quinn's bill to authorize the governor of New Jersey to appoint a state boiler inspector at $3000 a year passed the Assembly on Mar. 27. The House of Representatives some time ago defeated the bill.

If the bill becomes a law the state boiler inspector will be able to appoint three deputies at salaries of $1800 each.

Former Street and Water Commissioner Thomas P. Connelly, of Jersey City, who is a boiler maker, is among those named as candidates for the position of inspector.

The bill, according to the daily press, has the hearty support of the Boilermakers' Union and other labor organizations.

SOCIETY NOTES

The second annual banquet and entertainment of Local 472, International Union of Stationary Engineers, composed of the engineers of the public schools of Greater New York, will be held at the Broadway Central Hotel on Saturday evening, Apr. 26.

PERSONALS

J. M. Curtin, formerly assistant manager of the industrial and power department of the Westinghouse Electric & Manufacturing Co., at East Pittsburgh, has been appointed manager. Mr. Curtin is a graduate of Penn State College, and has been identified with the Westinghouse company ever since his graduation.

Homer Whelpley, secretary of the National Exhibitors Association, will resign on May 1 from the employ of Strong, Carlisle & Hammond to go with the Fisher Governor Co., Marshalltown, Iowa. His headquarters will be at 659 East 107th St., Cleveland, Ohio. With the latter company, Mr. Whelpley will be Eastern sales manager of territory comprising all states east of the Mississippi River, including the Southern states. He has been with Strong, Carlisle & Hammond about eight years as sales-manager of the steam specialty department, has been secretary of the National Exhibitors Association for the past two years and is now its vice-president.

Charles Robbins, since 1909, manager of the industrial and power department of the Westinghouse Electric & Manufacturing Co., has been appointed its assistant sales manager, with headquarters at East Pittsburgh. Mr. Robbins became associated with the company in 1899 and was for a number of years located in New York City. Previous to his connection with this company he was associated with the Cutter Co., of Philadelphia. He is a member of the National Electric Light Association and the American Institute of Electrical Engineers, having been closely identified with the latter organization in connection with the standardization work and prominently identified with the committee on rating.

Prof. Ira N. Hollis, of Harvard University, has accepted the presidency of the Worcester Polytechnic Institute, of Worcester, Mass. He was educated in the public schools of Louisville, Ky., and after a year's work in a machine shop was appointed to the U. S. Naval Academy. He graduated at the head of his class in 1878 and entered the Engineering Corps. The succeeding 15 years were spent in various work in the navy, both at sea and on shore. In 1893, while serving under the late Rear-Admiral Melville, he resigned to take the professorship of engineering at Harvard University. During 1892 he delivered a course of lectures at the Naval War College on "The Ships of Our Modern Navy." These lectures were afterward issued to the service in book form. At Harvard he was charged with the duty of developing the engineering instruction, and he remained at the head of the department for 16 years. In 1899, he received the honorary degree of A. M. from Harvard and has since received honorary degrees from other institutions. He is president of the Engineers Club of Boston, vice-president of the American Society of Mechanical Engineers, past-president of the Boston Society of Civil Engineers, and has served on the council of the American Academy of Arts and Sciences. He is a member of the Society of U. S. Naval Engineers, the American Society of Naval Architects and Marine Engineers, the Society for the Promotion of Engineering Education, and the Massachusetts Military Historical Society. He has contributed many articles to engineering and naval journals, and in intervals of leisure he wrote the "History of the Frigate Constitution."

NEW PUBLICATIONS

COMMERCIAL ENGINEERING. By Alfred J. Liversedge. Published by Emmot & Co., Ltd., Manchester and London, Eng. Cloth; 369 pages, 6x8½ in.; tables; indexed. Price, 7s. 6d. ($1.87) net.

The book reproduces a series of articles which appeared in the "Mechanical World" and is intended to fill the gap between college or apprenticeship and active responsible participation in business. It was written by a general manager, thoroughly familiar with his subject and covers a wide field dealing with materials, labor, facilities, productions, markets, tariffs, weights, measures and values in all countries; contracts, organization and legislation. Particular attention is given to the world's markets. The book gives a great deal of information in condensed form that would not be readily available, and besides helping the man breaking in, it should be valuable to the engineering man of business.

Advantages of the Steam Turbine

By John S. Leese

SYNOPSIS—A few of the advantages of the steam turbine over the reciprocating engine.

The differences in economy and general efficiency of turbines and reciprocating steam sets are of interest. In steam turbines are no rapid changes in direction of the moving parts or in stress resulting therefrom, thereby minimizing likelihood of failure from mechanical and structural defects.

The steady rotation of the turbine shaft reduces shafting and transmission troubles and is more adaptable for driving electric generators and textile mills than the comparatively uneven torque obtained with belt-driven reciprocating sets.

The cost of operating steam turbines, properly installed, designed and operated, is considerably less than that of reciprocating units, above a certain horsepower. This may be disputed from evidence to the contrary where reciprocating engines have shown more favorable results, but where the two types can be compared on the same basis, the turbine will make the better showing. The first cost is also less than that of a reciprocating engine for any sizes above 1000 kw. capacity.

The frictional load is less and, therefore, the mechanical efficiency higher. The frictional losses may be as much as 20 per cent. of the indicated horsepower of a reciprocating engine. Moreover, the turbine has almost no loss by condensation, as the stator casing and the rotor are kept at practically the temperature of the steam at its corresponding pressure throughout the range of expansion, owing to its continuous passage, and radiation is the only means of heat loss which would produce internal cooling.

The benefits from using superheated steam are not the same in the turbine and reciprocating engine, although they are considerable in both. The increased economy of the reciprocating engine using superheated steam is because of reduced initial condensation and valve leakage. The turbine benefits by the reduced frictional resistance offered to the rotor by the drier steam, in addition to the reduction of steam leakage past the blades.

Using superheated steam with a reciprocating engine is not always advisable, but turbines have no parts to be damaged by lubrication failures or by increased surface friction from undue expansion. Any unequal expansion occurring in a turbine running at high speeds, however, may throw the rotor out of balance or strip blading.

As a turbine requires no internal lubrication the condensed exhaust steam can be used as feed water.

The efficient operation of a condensing plant is encouraged more by turbines than by reciprocating engines, since the economies obtainable from "that last inch of vacuum" are considerably increased in turbine plants. Little is to be gained by striving for a better vacuum than 26 in. in a reciprocating plant, but the difference between the efficiencies at 26 and 28 in., and higher, with a turbine are worth attaining.

The disadvantages of the turbine compared with its reciprocating rival are few. Although the steam consumption per horsepower-hour is less than in a reciprocating engine so long as high speeds are maintained, it is considerably greater at low speeds. Reliable means of indicating a steam turbine are not available, but the developed horsepower may be approximately figured from the switchboard readings.

The introduction of the low-pressure and mixed-pressure turbines has attracted attention on account of the efficiencies and economies they have shown when applied to the exhaust of reciprocating engines. The mixed-pressure turbine is an exhaust-steam turbine with a high-pressure stage, to which live steam may be admitted, either to maintain the speed when the supply of low-pressure steam is insufficient or when it is absent altogether.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared for the construction of a waterworks system at Groveland, Mass. Estimated cost, $40,000.

The Andrew Terry Co. is preparing plans for the construction of a power plant in connection with its establishment at Terryville, Conn.

Plans are being considered by the International Brewing Co. for the construction of a boiler house in connection with its plant at Niagara and Albany Sts., Buffalo, N. Y.

The Consolidated Gas & Electric Co., Baltimore, Md., will construct an addition to its boiler house at Westport, Md.

SOUTHERN STATES

Plans are being considered by the Raeford Co. for the construction of an electric-light plant at Rockfish, N. C.

The Tidewater Power Co. is preparing to construct a substation at Winter Park, Wilmington, N. C. A. B. Skelding, Wilmington, is general manager.

Preliminary arrangements are being made by the Woodland Electric Light & Power Co. for the construction of an electric-power plant at Woodland, N. C. E. G. Griffin and C. J. Parker are interested.

An election will be held at Guyton, Ga., on Apr. 15, to vote on the proposition to issue $15,000 in bonds for the installation of an electric-light plant and water-works system.

The Columbus Power Co. contemplates the construction of a substation and distributing system at La Grange, Ga. Estimated cost, $35,000. J. S. Bleeker, Columbus, is manager.

The Ware County Light & Power Co. contemplates an expenditure of $50,000, for the installation of new equipment in its power plant at Waycross, Ga. J. Wright Reeve, Waycross, is manager and superintendent.

Bonds to the amount of $7000 have been voted for the construction of a water-works system at Fort Myers, Fla.

The citizens of Hurtsboro, Ala., at a recent election voted bonds for $14,000 for municipal improvements, including the installation of an electric-light plant.

The proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant and water system at Henderson, Tenn., is under consideration.

Elmer Northcutt, of Chicago, Ill., has applied to the city council of Irvine, Ky., to construct and operate an electric-light plant and water system at that place.

The municipal electric-light plant at Midway, Ky., has been purchased by the Kentucky Utilities Co., of Lexington, Ky. Extensive improvements and extensions are planned by the new owners.

CENTRAL STATES

The Petersburg Electric Light & Power Co. has been granted a franchise to construct and operate an electric-light plant at Loogootee, Ind. George E. King, Petersburg, Ind., is manager.

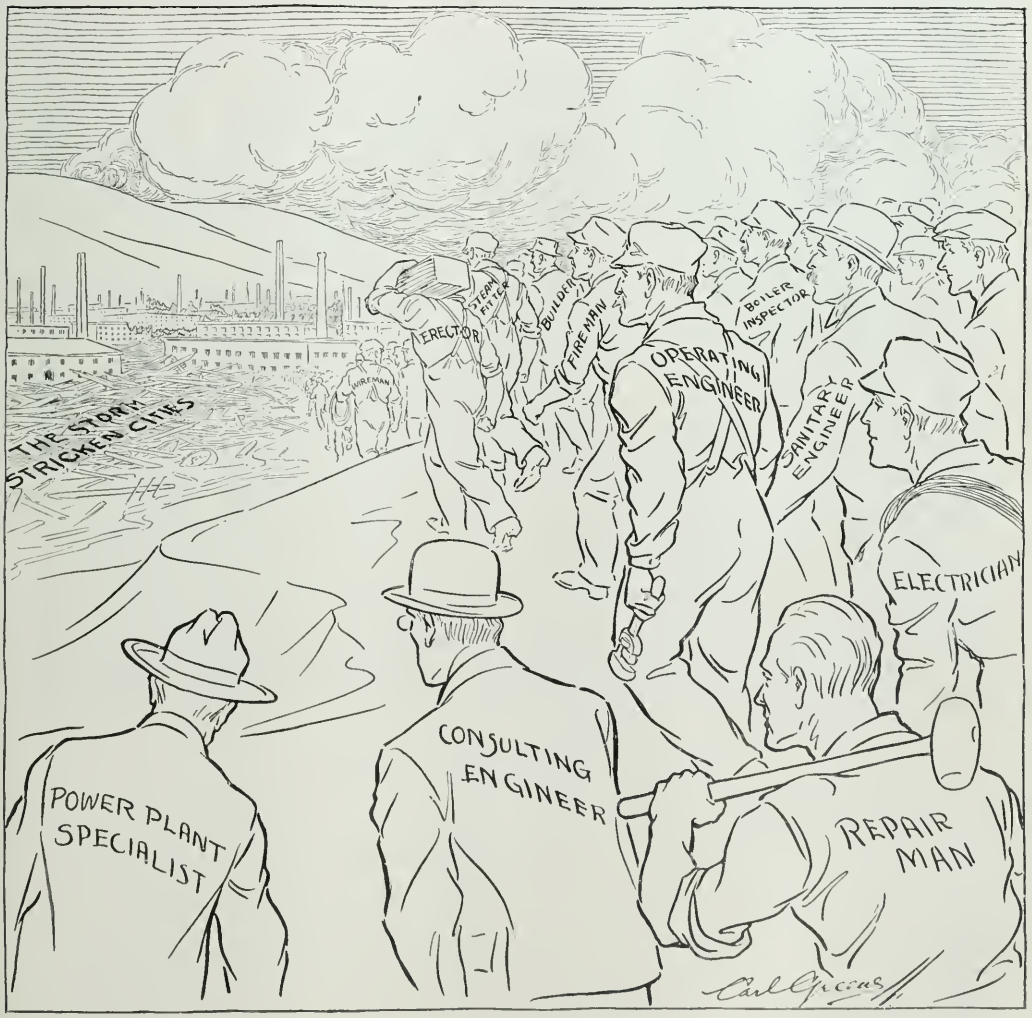
Bids will soon be received by Gardner S. Williams, consulting engineer, Ann Arbor, Mich., for the construction of a power plant and dam for the Eastern Michigan Edison Co., at Belleville, Mich. Estimated cost, $450,000.

Plans are being prepared by B. K. Goodman, chief engineer of Reading, Mich., for the installation of new power-plant equipment, including boilers, engine and generator for the local electric-light plant.

The Western United Gas & Electric Co. is preparing plans for the installation of additional equipment in its power plant at Aurora, Ill.

POWER

Vol. 37 NEW YORK, APRIL 15, 1913 No. 15



ANSWERING THE CALL OF INDUSTRIAL DISTRESS

Condensing Equipment of Lake Shore Plant

By A. D. Williams

SYNOPSIS—A general description of the Lake Shore plant of the Cleveland Electric Illuminating Co. appeared in the Mar. 18 issue. The present article deals with the intake and discharge conduits and basins, the surface condensers and the condenser auxiliaries.

The base condensers in the Lake Shore plant are of the two-pass type, the exhaust from the turbines flowing into them through free annular openings. The vapor and condensate both flow downward, the condensate collecting in a well from which it is drawn off and pumped to the feed-water heaters by a volute pump. The air or dry-vacuum pump suction is located close to the tubes of the

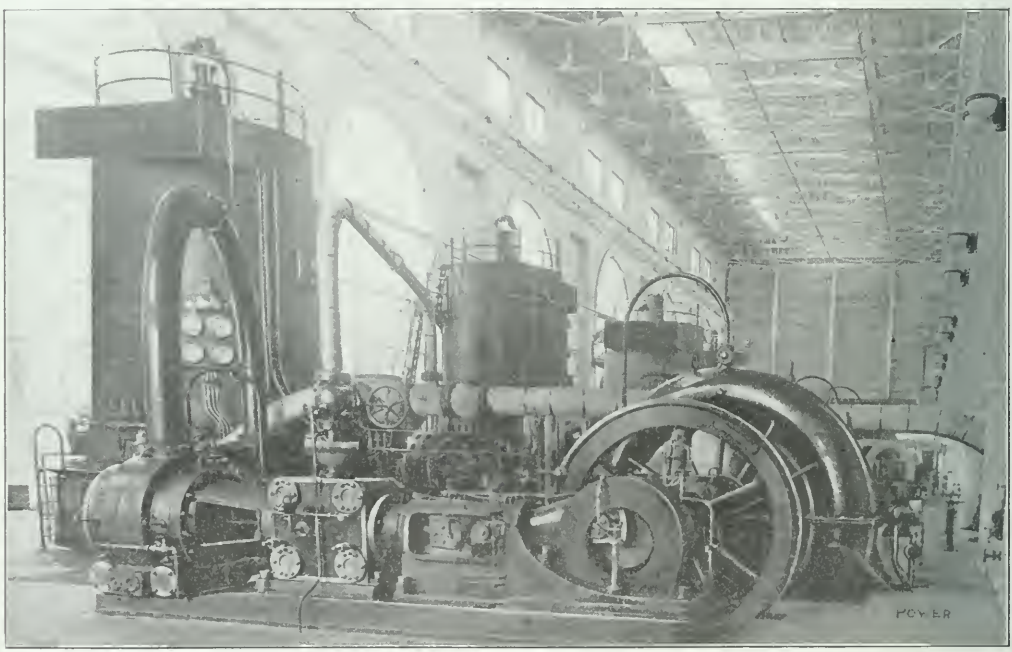


Fig. 1. Dry Vacuum and Circulating Pump for Unit No. 1

first or coldest water pass in order to avoid the use of a precooler for reducing the density.

Lake Erie, which furnishes the circulating-water supply, is subject to very slight fluctuations in level and whatever current there is has a slight set toward the east, except when infrequent easterly storms set up surface currents flowing toward the west. To separate the intake and discharge water, an intake channel, formed by two parallel moles of concrete, has been built out into the lake at the west end of the plant. These are of extremely heavy construction and the entrance to the channel is obstructed by piling to prevent blocking of the channel by the heavy ice flows in the spring. The pier on the east side of the channel has a right-angled turn, parallel with the front of the building, and forming a basin divided in two sections by a wall of sheet piling tied together at the top. The section of the basin immediately alongside of the building forms the intake forebay from which the cooling water is drawn. The discharge pipes, in pairs, pass under this forebay and, rising close to the surface, discharge into the outer basin. Connecting gates are placed at the west end of the outer basin so that the warmer water from the condensers can be discharged into the intake forebay to prevent the formation of ice in extremely cold weather.

Each intake is provided with four screens, arranged in two sets, each set consisting of two screens in series, so that any screen may be raised for cleaning without interrupting the flow of water to the condensers. In addition there is a gate frame at the mouth of the conduit so that it can be closed off and pumped out, if necessary for cleaning or inspection. The mouth of the discharge can be closed by stop logs or needles, when necessary.

The intake and discharge conduits are 5 ft. in diameter and of reinforced concrete. The intake is above the discharge for the same unit and the conduits for each group of two units are run in the same trench. Inside the building the discharge conduits turn out and up, as shown in the plan, forming the discharge well. The intake conduits continue to the other side of the basement, where they turn to join the intake well. The bottoms of these wells are 16 ft. below the level of the lake and the circulating pump-suction pipes are submerged 5 ft., the discharge draft tubes having the same depth.

In each case the dry-vacuum and the circulating pumps

have been combined in a single Corliss engine-driven unit. The load on the circulating pump is confined to the friction head of the cooling-water piping and the power required to maintain the column of water in motion. The starting head, however, corresponding to the power required to set the column of water in motion, is considerable and this occurs when the load on the dry-vacuum pump is at a minimum; hence, considerable economy results from combining the two in one unit. The circulating pump is of the single-stage type with double-suction pipes, its center line being about 16 ft. above the normal level of the lake and about 8½ ft. above the center of the condenser, to which it is connected by a special offset bend. This arrangement of piping permits all of the auxiliary apparatus, except the condensate pump, to be located upon the main floor of the turbine room. At the same time it slightly increases the suction lift in starting and the friction head in operating.

CONDENSING DATA

	Wheeler Units Nos. 1 and 2	Alberger Units Nos. 3 and 4
Rated capacity of generating units, kv.-a.	9000	14,000
Steam pressure, lb. per sq.in.	215	215
Condensers—nominal vacuum in inches of mercury	28 00	28 60
Pressure, lb. per sq.in.	0 980	0 686
Circulating water—initial temperature deg. F.	70 00	60.00
Square feet of cooling surface, per condenser	16,000	25,000
Square feet of cooling surface per kv.-a.	1 777	1 785
Number of 1-in. tubes in condenser	3592	5620
Nomiual capacity of condenser,		
Pounds of steam per hour	140,000	224,000
Pounds of steam per square foot of cooling surface per hour	8 75	8 96
Pounds steam per hour per kv.-a.	15 59	16 00
Number of water passes in condenser	2	2
Velocity of cooling water in tubes, ft. per min.		450
Cooling water pumps—double-suction, single-stage		
Diameter of discharge, inches	30	36
Nominal capacity, gal. per min	24,000	30,000
Pounds of water per minute	200,169	250,000
Pounds of water per pound of steam	85 80	67 47
Speed of cooling water pump, r.p.m.	65–110	100–150
Circulating water intake and discharge		
Diameter of conduit, ft.	5 00	5.00
Bottom of intake and discharge pipes below normal lake level ,ft.	8 5	
Bottom of suction and discharge wells below normal lake level ft.	16.0	
Submergence, suction and discharge pipes, normal lake level, ft.	5.5	
Height of center line of cooling water pump above normal lake level, ft.	16 00	
Variations in lake level—		
Above normal, ft.	1.85	
Below normal, ft.	1.15	
Approximate velocity of flow in conduits, ft. per sec.	2 73	3.40
Hotwell pumps—centrifugal, single-stage		
Suction, diameter inches	8	6
Discharge, diameter, inches	4	5
Capacity, gal. per min.	300	675
Pound of condensate per hr.	150,000	337,500
Speed, r.p.m.	2,000	2,200
Motors, Terry steam turbines.		
Dry vacuum pumps—single-stage with flash ports—		
Air cylinder, in.	30x18	34x24
Steam cylinder, in.	16x18	20x24
Speed, r.p.m.	75 to 110	100 to 150

The condenser for unit No. 5 is similar to those for units Nos. 3 and 4

The suction pipe of the air cylinder connects with the coolest portion of the condenser and forms a large radius

FIG. 3. SURFACE CONDENSERS

bend to the top of the cylinder. These pipes are of large size to minimize friction losses, and the exhaust is carried into the free exhaust line just outside of the back-pressure valve. Flash ports are provided for equalizing the pressure in both ends of the cylinder at the commencement of each stroke and the ends and barrel of the cylinder are water jacketed.

The hotwell pumps are placed in pits below the level of the basement floor. They are connected to the hotwell by large suction pipes and the highest point in their casing is vented back to the condenser to prevent their becoming vapor bound. The discharge is piped to the feed-water heaters from which it is drawn by the boiler-feed pumps. These pumps are single-stage centrifugals driven by small steam turbines. The exhaust steam from the condensing equipment, together with that from all of the other auxiliaries is delivered to the feed-water heaters.

Each unit is provided with a free exhaust back-pressure valve and an independent atmospheric exhaust line.

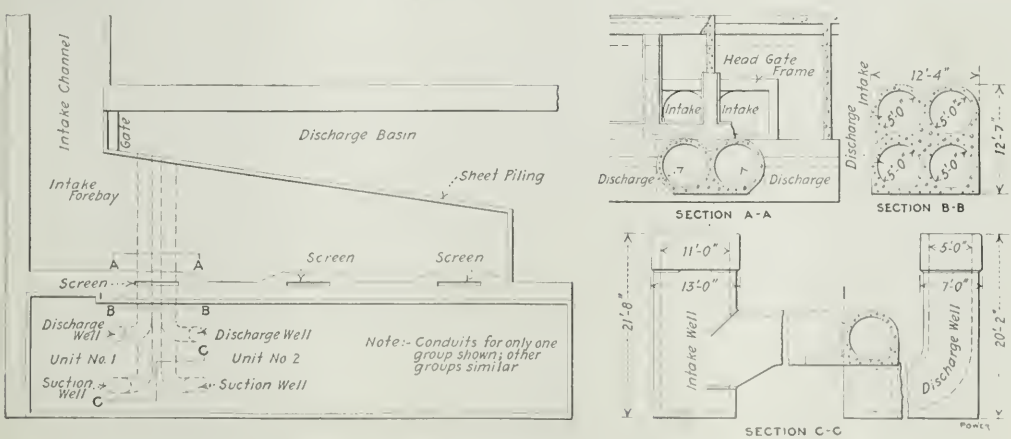


FIG. 2. PLAN AND SECTIONS THROUGH INTAKE AND DISCHARGE TUNNELS

Stresses in Unsymmetrical Boiler Joints

SYNOPSIS—Account of an experimental investigation of the above subject, conclusions of which were that the maximum fiber stresses may be two to four times those for which the joint was designed, that most joint failures are due to unsymmetrical design, that boiler parts subject to bending action particularly should be inspected for incipient cracks and that pitting should be watched as likely to start cracks.

A paper of interest to all concerned with the question of the failure of lap boiler joints, in the manner commonly known as "lap-joint cracks," was presented to the Engineering Association of New South Wales, by S. H. Banaclough and A. J. Gibson.

The paper is in two parts: The first deals with the explosion of two locomotive boilers constructed with lap joints, discussing the theory of the action of a lap joint under pressure and the probable cause of the formation of the so called, lap-joint cracks. The second part recounts an extended series of tests which show the actual maximum fiber stress as determined by measurement of the strains in the plate adjacent to the joints.

One of the explosions consisted of the upturning of the outer side plate of the furnace of the locomotive boiler, constructed with a separate sheet to form the wagon top, instead of a continuous wrapper sheet. The side sheets were lapped outside of and joined to the top sheet by double-riveted lap joints. The fracture started from the inner surface of the side sheet and closely followed the edge of the top sheet, working its way toward the outer surface until the sheet was so weakened that it upturned under the usual pressure, 140 lb.

The fractured joint was at, relatively, a short distance above the stay-bolted surface. This fracture was 40 in. long and extremely straight. At each end of it, near the head and barrel joints, were numerous small cracks and to open them for examination the sheet was bent down at the corners with hydraulic pressure. A close examination before bending, indicated that they were small cracks and groovings. Some appeared as shallow grooves—about $\frac{1}{32}$ in. deep and $\frac{1}{16}$ in. wide, and had the appearance of marks made by a blunt chisel but in no way resembling serious cracks. Bending the plate back, however, showed a crack at the bottom of these grooves which extended about one-third through the plate. A microscopic examination indicated that all the cracks originated as grooves with well rounded edges and at the bottom of the grooves were fine hairline cracks.

Fig. 1 shows how the cracks are supposed to develop. The fractured plate was of low moor iron $\frac{9}{16}$ in. thick and results of physical tests of seven different samples taken from various parts of the plate averaged 49,658 lb. per sq.in. tensile strength, with a 27.1 per cent. reduction in area at the fracture and 16.1 per cent. elongation in 8 in. These figures represent good average quality and normal ductility for this material.

Bending and twisting tests showed that the grain of the material ran at right angles to the joint line, as it should. Having, practically, eliminated, by these tests, the quality of the material as a factor in producing the cracks, it was observed that such cracks occur only at joints where the surface strains are very variable and abnormally high. It is shown by a method of movements that in a riveted joint, formed by lapping two plates of equal thickness, when it is subjected to a straight pull tending to separate them at the joint, the maximum fiber stress along the two surfaces in contact will rise to a point where it equals four times the stress produced by the direct pull on the plate. Also, the opposite surface may have a compressive stress, in the vicinity of the joint, of twice the amount of the direct pull.

These conclusions were verified by tests described in the second part of the paper. It is pointed out that this maximum stress cannot occur along the part of the joint directly between the rivet holes, which constitutes the net section of the plate and is the section always used as a basis for determining the strength of the joint as far as the plate is concerned. It is also noted that the particular form of the joined ends of the plates, with respect to the true cylindrical shape of which they are assumed to form a part, will have a material bearing on the maximum surface stress that may be produced in the plates.

Examination of the corresponding joint on the other side of the boiler seemed to indicate the possibility of a pitting action or fracture at one point in its length and the rivets were removed and the plates separated.

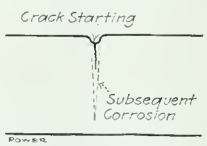


FIG. 1. HOW CRACKS GROW

The surface which had been covered by the lap of the other plate indicated some slight pitting or grooving along the line that had been occupied by the edge of the underlapping plate, but nothing that would suggest that the plate was not as good as new.

Subsequently, the entire plate was removed from the boiler and the part which had formed the joint was placed under a hydraulic press to develop any incipient cracks that might not have become visible. This showed that the plate was cracked almost its entire length and, practically, through to its outer surface, similar to the sheet which had caused the explosion.

The second exploded boiler was of steel plate $\frac{3}{8}$ in. thick. The fracture followed the line of rivet holes. It was along one of the seams of a barrel course and occurred in the underlapping plate, the one to which the boiler dome was attached. Physical tests of two pieces of this plate, taken from near the rupture and at right angles to each other, showed an average tensile strength of 62,426 lb. per sq.in. and contracted in area 48.2 per cent. and elongated before fracture to 24.2 per cent. in a length of 8 in.

The fractured plate showed that most of the holes had been punched full size and numerous small cracks were observed around the rivet holes; these being attributed to injury done the metal in punching the holes, as no defect was shown in the quality of the material by the physical test. It is pointed out, that, no matter whether

it is the underlying or overlapping plate which cracks, the fractures always commence on the surface whose fibers are subjected to the highest tensile stress and they work toward the surface of compression or low tensile stress. If the conclusions regarding the formation of lap cracks due to high surface tension along certain lines parallel to the joint, are correct, it is pointed out that similar unusual stresses will be developed in other parts of a boiler where the form tends to produce unsymmetrical loading of the parts. Such parts are dished heads, and parts of the shell adjacent to reënforcements similar to those used around manhole openings or for the attachment of valves or other fittings.

The general conclusions at which the authors arrived were as follows: The failure in each case was due, primarily, to the high surface stress which is characteristic of all places lap-joint cracks occur. The failures were not due to any defect in the quality or structure of the material of the plate.

High proof-pressures should be avoided on boilers, especially old ones, since they only tend to aggravate the trouble.

Much valuable information might be obtained by a close study of the plates in the neighborhood of riveted joints when old boilers are being broken up. The closest scrutiny should always be given to boilers with lap joints, and, especially, to their joints. No suspicious signs in lap joints should ever be neglected and the internal in-

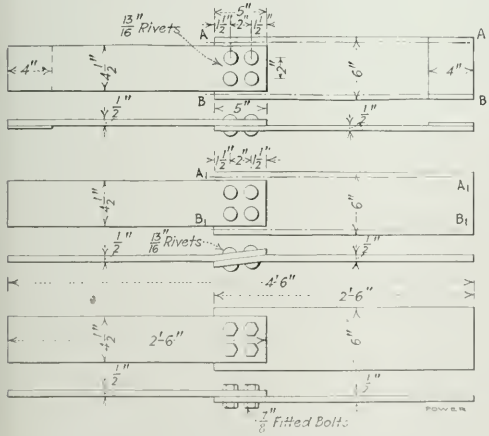


Fig. 2. Experimental Lap Joints

spection of lap-jointed boilers should be more frequent than when fitted with butt joints. Above all, the conclusion is that riveted lap joints should not be employed under any circumstances in boiler construction.

Tests Showing Measurements of Strains in Boiler Joints

The second part of this paper describes three series of tests of lap joints, both in testing machines and in actual construction, where an internal pressure is used to produce the loading of the joints. For the machine tests, three samples were made up, as shown in Fig. 2, and these had varying loads applied to them by a testing machine as will be described later.

The first test joint was made up of straight plates riveted together. The second had the plates already formed (adjacent to the joint) to the position which they would tend to occupy under a load acting to pull them apart. The third test piece was made like the first, except that turned bolts were fitted in the holes in place of rivets. One of the plates forming these joints was wider than the other. This construction was used so that the joined surface of one of the plates might be available for measurements throughout its entire length. In the tests, measurements were made of the extension of the fibers on the surface of the side plates along the test lines $A1$—A_1A_1 and BB and B_1B_1. Since the extension of these fibers is proportional to the others (within the elastic limit) such

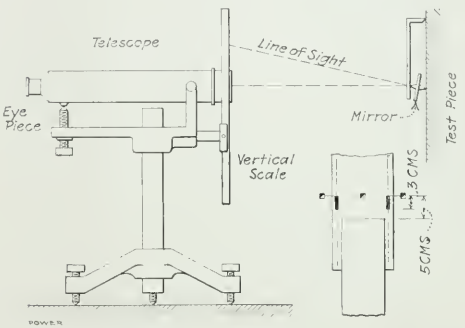


Fig. 3. Fig. 4

Martens Mirror Extensometer as Originally Employed

measurements would indicate the relative stress at the different joints at which the measurements were made for the various loads applied.

The measurements of the surface extension along the test lines were made with a Martens mirror extensometer, shown in Fig. 3. This consists of a bar held at one end of a fixed joint on the test piece and with the other end resting on a prism to which a mirror is attached and one side of the prism also rests on the test piece. Any change in the length of the surface of the test piece between the two points upon which the bar and prism rest will tend to rotate the prism and, therefore, the mirror, and measuring of the angle through which it is rotated, indicates the relative amount of extension. To prevent displacements of the test piece as a whole from affecting the readings, additional mirrors were attached directly to the test piece in line with the extensometer mirror, as shown in Fig. 4.

The elimination of the effect of all movements of the surface carrying the extensometer, other than its elongation under strain, was difficult as the surface of the plate under test tended to rotate in the vicinity of the joint, due to the bending action produced by the change of form. In the first series of tests, this was cared for by attaching a mirror so as to indicate the amount of rotation of the surface upon which the prism of the extensometer rested.

Readings were taken at seven different positions along the test lines $A1$ and BB, Fig. 2; the loads on the test pieces being raised from 0.2 to 3 tons by increments of 0.2 ton each. Curves were drawn from the results obtained at each test joint by plotting the mirror readings

against the loads producing them. In each test the maximum load was applied twice at readings taken at the various loads, both with the load ascending and descending. Fig. 5 shows a complete set of readings for one test point and the line represents the average. The values, represented by this line of average, were used instead of the individual readings as an aid to accuracy.

From a set of diagrams like Fig. 5 (made up from the tests at various points along the surface of the test piece) values were selected corresponding to a load of three tons

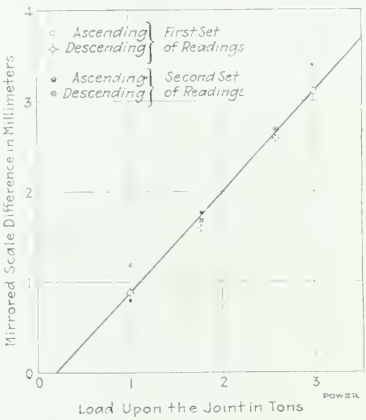


FIG. 5

and a strain diagram, as shown in Fig. 6, constructed. The upper part of this curve indicates, by its relative distance above line *OA*, the varying strain in the fiber along the surface of the plate at *AA*, and the line parallel to *OA* passing through *C* indicates, by its distance above *OA*, the estimated amount of strain on the fibers, if the test piece had only been subjected to a direct load

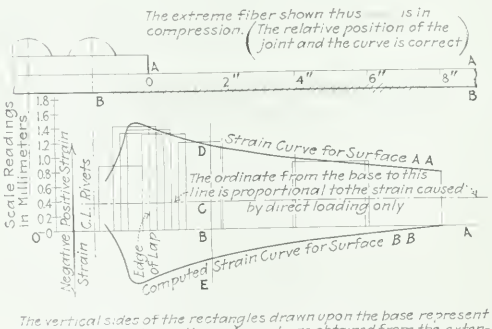

The extreme fiber shown thus is in compression. (The relative position of the joint and the curve is correct)
Scale Readings in Millimeters
Negative Strain
Positive Strain
C.L. Rivets
Edge of Lap
Strain Curve for Surface A A
The ordinate from the base to this line is proportional to the strain caused by direct loading only
Computed Strain Curve for Surface B B
The vertical sides of the rectangles drawn upon the base represent the difference between the scale readings obtained from the extensometer and fixed mirrors in their several positions. The vertical ordinates of the curve are proportional to the actual strain in the extreme fiber
POWER

FIG. 6. STRAIN CURVES FOR LAP JOINT

of three tons. The power curve indicating a compressive strain on the opposite side of the plate (*BB*) has been calculated from the values given on the upper curve by considering that the stress in both surfaces *AA* and *BB*, due to the bending action alone, must be equal and opposite. By combining the compression values with those calculated for a direct load of three tons the stress along the surface *BB* is found. This is accomplished by making the length of ordinates above and below the horizontal line, representing the strain for three tons, equal.

Significant and interesting is it that the indicated maximum strain in a lap joint, as shown by this test, was 3.9 times the amount produced by the direct pull and, therefore, agreed remarkably with the theoretical maximum value of four times the amount of this pull as determined by movements. The test piece with the joined ends of the plates already bent (see Fig. 2), was next tested similarly and the maximum fiber stresses along the surfaces were found to be materially reduced below those developed in the first specimen tested. These stresses were never double those produced by the direct load. The curve for strains in this test specimen is plotted in Fig. 7.

It will be seen in Fig. 7, that the strain curves vary only slightly from the line representing the effect of direct load at the point where the fractures usually occur. It is pointed out, that, while the stresses in the plate are materially reduced by thus forming the joint, the stresses on the rivets are evidently increased.

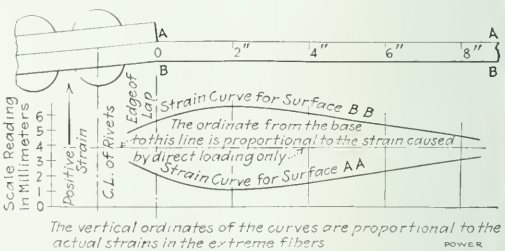

Scale Reading in Millimeters
Positive Strain
C.L. of Rivets
Edge of Lap
Strain Curve for Surface B B
The ordinate from the base to this line is proportional to the strain caused by direct loading only
Strain Curve for Surface A A
The vertical ordinates of the curves are proportional to the actual strains in the extreme fibers
POWER

FIG. 7. STRAIN CURVES FOR JOINT WITH FORMED ENDS

In using the fixed mirrors to eliminate errors caused by movement of the test piece as a whole, it was found that the amount of movement indicated by these mirrors depended upon the position which they occupied with respect to the riveted joint, and an investigation showed that the extensometer was not actually needed to measure the extension along the surface, for a series of fixed mirrors along the test line would indicate the relative amount the surface was bent at the various test points, and be a measure of the stresses produced by the bending action. To these indications could be added the calculated stresses due to direct loading which would give the total surface stress. This was known as the fixed-mirror method of testing.

A second series of tests was next undertaken, by the fixed-mirror method, which seemed to be particularly adapted for use on the shell of a boiler, because the fouling of the extensometer mirror on the shell was avoided. The load on the joints was produced by internal pressure, as it is actually. A Babcock & Wilcox drum, with a double-riveted lap seam, was used as one of the subjects for this test and the stresses were measured along a circumferential line crossing the joint and extending half way around the drum. These tests indicated that, for this joint, the maximum surface stress at the seam was, roughly, twice what would have been expected from direct loading such as would have been obtained if the drum had been a true cylinder without joints.

The drum was 36 in. in diameter and made up of three courses. The plate was ½ in. thick and the girth line, along which the observations were taken, was in the center course (an inner course) and 15 in. from the calking edge of the nearest girth seam. An interesting fact was developed by taking the observations over such a long line and which tended to confirm the accuracy of the observations. The solid plate of the center course opposite the line of joint on the end course exhibited under test a similar variation in the amount of stress as shown at the joints. Notwithstanding the distance of 15 in. between the end of the joint of the end course and the test point on the center course, the effect of this joint on the solid plate was to produce a maximum stress in the plate of, practically, one-half the amount shown at the tested joint. The location of the test line with respect to the joints is shown in Fig. 8.

Since the fixed-mirror method of testing did not take account of the total stress, but necessitated adding the calculated stress produced by direct loading, a third series of tests was made using a modified form of the Martens mirror extensometer.

On this form of extensometer, the fixed mirror was attached directly to the extensometer bar and the extensometer mirror was attached to its actuating prism by a link which brought it away from the surface of the plate. This arrangement eliminated any rotation of the fixed mirror due to disturbance of the surface of the test piece and also prevented the fouling of the extensometer mirror against the shell of the boiler. The bolted specimen, shown in Fig. 2, was tested with this modified form of extensometer and simultaneous readings were also taken during this test with fixed mirrors. The results were plotted for both plates and showed remarkable uniformity between those obtained by the two different methods of testing.

Testing riveted joints in this manner naturally suggested tests of other parts of boilers, such as dished heads. Tests of this kind indicated that the maximum stress on the inner surface of a bumped head is along the turn of the flange at the point where grooving is most likely to develop. The actual measurements in all cases during these tests were of stress and the assumption was made that the stress was proportional to the strain. Also, that the modulus of elasticity is taken at 29,000,000 lb. per sq.in. In boilers under pressure, the material is strained in two directions at right angles to each other and, under these conditions, the modulus of elasticity may change.

The authors' general conclusions are:

That in an ordinary straight-plate lap joint the maximum fiber stresses may amount to about four times the stress for which the joint is actually designed. In lap joints in boilers, owing probably to the stiffening effect of contiguous parts of the boiler, the extreme fiber stress may amount to about twice the stress for which the boiler is designed.

That "typical lap-joint failures," as the result of the extreme stress conditions present in this type of joint, are due to the want of symmetry in the design.

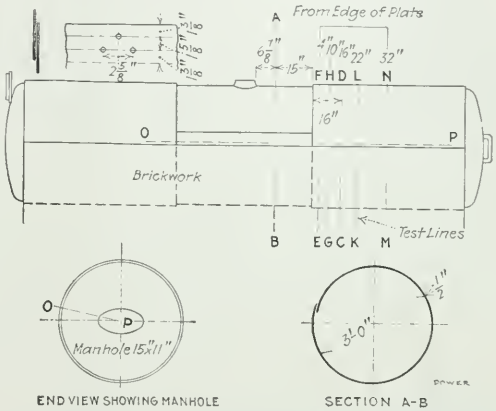


Fig. 8. Boiler Drum (B. & W. Type)

That in the inspection of boilers particular attention should be paid to those parts where it is known that bending actions can occur and that these parts should be most carefully examined for incipient pitting and surface cracks.

That where pitting has been noticed, its progress should be very carefully watched and should it exist as a line of pit marks for any considerable distance, the examination should be most particular as the cracks run from one pit hole to another and the condition of the shell may be such as to be dangerous.

Wages in the Amazon River Valley

By Hubert E. Collins

SYNOPSIS—Number of men employed, wages and methods of working in Brazilian power plants.

Within the limits of the two principal cities of the Amazon River valley, Para and Manos, the same wages prevail. Within these boundaries, the rates given in the accompanying table apply. If the work is outside of these cities, then traveling, living and medical expenses are added. Many times an increased rate of wage is also asked in connection with outside work.

Within each of these two cities, there is an electric-light and railway plant, port works, water-works, gas works, rope works, sawmills and a brewery. All of these employ some one or more of the classes of help here enumerated, and the rates hold good in any of these industries. The men are all natives and give good service if properly trained. They like to excel and are anxious to learn any trade connected with engineering. They are good imitators but poor originators, so that the heads of departments are generally European. The accompanying photographs show some native power-house assistants in Para, Brazil.

In the table, native Portugese names of positions and the English equivalent are given, and the rates are also

given in Brazilian and American denominations. A reis is the smallest Brazilian currency. One thousand reis or one milreis is at the present time equal to $0.314 American money. The following comparative rates are figured at this ratio. The method of setting down the sums should be noticed. One milreis = 1$000. One

WAGE RATES IN THE AMAZON VALLEY CITIES

Positions	Hours per Day	Pay in Brazilian Money	Pay in American Money
Machinistas, engineers	12	425$000	$133 a month
Premeira ferralheiro, first assist. engineer	12	525$000	$165 a month
Electricistas, switchboard attendants, electricians	12	10$000	$3.14 a day
Foguinistas, firemen	8	7$500	$2.36 a day
Lubrificadores, cleaners	12	4$000	$1.26 a day
Comedor d'agua, water tenders	8	8$000	$2.51 a day
Carvoliros, coal passers	8	160$000	$50 a month
Premeira classe ferralheiros, machinists first-class	10	425$000	$133 a month
Segund classe, second-class Helpers	10	400 to 1$000 200 reis	13 to 31c. an hour 6c. an hour
Carpenteiros, carpenters	10	700 to 800 reis	22 to 25c. an hour
Pedreios, masons	10	400 to 800 reis	13 to 25c. an hour
Ferreios, blacksmiths	10	400 to 800 reis	13 to 25c. an hour
Internos, helpers	10	200 to 600 reis	6 to 19c. an hour
Premeira interno, foreman	10	160$000	$50 a month
Vigias, watchmen	12	160$000	$50 a month
Apontador, time-keeper	12	200$000	$63 a month
Electricistas, lamp trimmers, wiremen, repair men	12	400 to 700 reis	13 to 22c. an hour

hundred milreis = 100$000. The dollar sign ($) is always placed at the left of three figures.

Since the United States' demonstration of the efficacy of sanitation at Panama, all the cities in the tropics have copied the same methods. The result is that European people or Americans can live here if they take reasonable care of themselves. It may interest some to know the salaries paid to heads of departments. The salary generally includes transportation to and from quarters, medi-

GROUP OF FIREMEN IN PARA, BRAZIL

cal attendance, vacation with pay, and table board. In some instances the table board is not included. In this event, the men club together and live in staff houses.

General Manager of Railway & Lighting Co.	$9,000 a year
Chief Engineer	6,000 a year
Master Mechanic	6,000 a year
Superintendent of Transportation	4,800 a year
Superintendent of Lines	4,800 a year

On the Amazon River there is an ever increasing traffic employing marine engineers and pilots, all of the latter being natives. Most of the chief engineers are licensed by the government. Engineers are graded first, second and third class. Applicants must go to Rio de Janeiro to be examined for a first-class license; to Para for a second-class license; and to Manos for a third-class license. A fee of 200, 150 and 100 milreis, respectively, is charged the applicant. The pay of these men ranges from 400 to 600 milreis per month and living expenses. The pilots receive 600 milreis per month

BRAZILIAN TIMEKEEPER AND CABOCCA HELPER

on duty and 300 milreis while on shore, awaiting orders.

The writer believes, that with proper instruction and discipline, the same amount of labor can be obtained from the natives in Brazil as from men foreign to the country. It must be borne in mind that tropical conditions exist in the two cities mentioned. The Amazon River from its mouth to Manos, a distance of over 1100 miles, is within four or five degrees of the equator. In either one of the cities the temperature every day in the year is never less than 86 deg. F. at night, and, of course, the heat is more intense during the day. For this reason it is not expected that any class of help can do as great an amount of work as in a temperate zone.

Some idea of the amount of labor required may be obtained by an analysis of the working force of a 3000-kw. power plant in one of these cities. The number of men employed in this plant is 110, consisting of one chief engineer, one first assistant engineer, four assistant engineers, five switchboard attendants, seven oilers, eight cleaners, two water tenders, seventeen firemen, four coal passers, three blacksmiths, fifteen machinists and repairmen, two masons, three carpenters and thirty-eight helpers.

By referring to the wage list, it may be noticed that the firemen, water tenders and coal passers work in eight-hour shifts. The peak load always comes during the hours of the afternoon and evening watch, 4 to 12 o'clock. At that time one fireman is stationed at each boiler in service, and for about four hours of his watch handles over a ton of coal an hour. The firemen are shifted every week so as to give each a turn at the lighter work of their

department. At the time the observation was made, the total coal consumption of this plant averaged 40 long tons a day of 24 hours, so that the average amount of coal handled by the firemen is 0.23 long ton per man. The coal is run in on a trestle and dumped in front of the boilers. The coal passers move from one fire to another and shovel the coal close up in front of the boilers so that the firemen always have their coal within reach when charging a boiler. The boilers are also attended by water tenders so that the firemen do not need to perform this duty. During the afternoon watch the firemen are compelled to work their forces almost incessantly. They are in a dripping perspiration within five minutes after they come on duty, and they are in that condition until they stop working. When fires are cleaned, the coal passers clean out the ashpits and haul away the ashes.

In this plant the chief engineer takes charge during the day, and the first assistant engineer is required to take charge of the boiler and engine room during the night. There are two assistant engineers on the floor at all times, and it is their duty simply to start and stop engines. There are four oilers on duty during the night, and three during the day. They attend to the engines and condensing machinery.

There are eight cleaners who work in 12-hour shifts, and it is their duty to mop floors, wipe engines and generators and keep the switchboards clean. The switchboard attendants are in the gallery at all times and have nothing to do with the generators. In addition to these men, there are blacksmiths, machinists, repairmen, masons, carpenters and helpers, all of whom work during the day.

It was found upon observation and careful study, that this total working force could be greatly reduced. By a gradual process of rearrangement, the number of oilers was cut down to three; the number of helpers was reduced to ten; one blacksmith and two machinists and repairmen were retained. The masons and carpenters were disposed of entirely.

Among the machinists and repairmen there are men who were trained to keep the boilers clean, and to repair the brickwork wherever it was necessary. At least one boiler was taken down each day to have the tubes swept and for any necessary repairs to the brickwork or baffles. Among the helpers there are men who also operate the coal cars, running the coal in from the bunkers to the boiler room.

In handling these men, a great deal depends on the man in charge. If he will exercise due patience, and will be explicit in his instruction so that the men understand everything he tells them, they appreciate it and try to do their best. To be connected in any way with engineering is always considered a great honor among these people.

Most of these men are steady workers, some of them having worked from ten to twelve years in the one place, and over half of them for at least two years. Among those who come and go there are quite a number who are trained in some department of power-plant operation, so that it is possible to pick up men in each of these cities who are trained workers.

Recent Developments in Turbine Reverse Buckets

By O. D. H. Bentley*

SYNOPSIS—In turbines of the Riedler-Stumpf type the presence of the nozzle causes the steam to be redirected upon the wheel not at the edge but somewhat toward the center of the receiving bucket. The article describes a nozzle block designed to overcome this defect.

In a single pressure, multiple velocity-stage turbine, such as described herewith, there is no question but that the nozzle and reversing chambers contribute more to the performance or efficiency of the turbine than any other parts. In other words, the initial nozzle and reversing chambers are the vital parts of the turbine, as far as practical results are concerned, and because this fact has been realized by the majority of steam-turbine designers, a great deal of thought has been concentrated on these details of the turbine.

It is surprising to note the variable results that can be obtained by slight changes in these nozzles and reversing chambers. For instance, Fig. 1 shows a photograph of a nozzle which has been used with considerable success, the water rate of this nozzle plotted against speed being shown by curve *a*, Fig. 3. Likewise, the results obtained by the nozzle and reversing chambers, shown in Fig. 2, are plotted in curve *b*, of the same figure. The difference in results is probably wholly attributable to the reversing chambers, and to the reversing chambers forward of the rear supplementary reversing chamber, for this latter and the initial nozzles are identical in each case.

A positive explanation of this difference would be difficult to make, but the writer believes that it is caused by the inefficiency of the small reversing chamber, shown in Fig. 1 alongside of the initial nozzle. That is to say, the steam coming from this small reversing chamber is directed into the bucket wheel, as illustrated in Fig. 1, and instead of being delivered at the side of the bucket, as it should, it is discharged into the center, as shown, and must necessarily mingle with, and interfere more or less with the nozzle steam. It is a well known fact that the best results cannot be secured if two streams at different speeds are allowed to mix, for they cause eddies which reduce the velocity.

Fig. 5 shows the corresponding reversing chambers for nozzle No. 2. There is, in this construction, no reversing chamber which corresponds to the smaller reversing chamber which is alongside the nozzle in Fig. 1. The first reversing chamber which, as shown in Fig. 5, is just forward of the nozzle, delivers its steam at the outside of the wheel bucket, while, in addition, the steam films are better separated, and it seems reasonable to assume that this is the principal reason why the nozzle illustrated in Fig. 2 gives the higher efficiency.

By referring to the characteristic curve *a*, in Fig. 3, compared with curve *b*, it will be seen that the efficiency of nozzle 1 increases the faster as the speed is increased,

*Manager of the Turbine Department, B. F. Sturtevant Co.

which would bear out the above reasoning that the small bucket alongside of the initial nozzle in segment No. 1 is less detrimental as the speed is increased. In other words, the speed of the wheel carries the steam further forward in the direction of rotation. Consequently, a smaller percentage of the steam is delivered into this small reversing chamber as the speed increases.

It has been found by experiment that the best efficiency can be obtained when the initial steam jet entering the wheel of this type does not exceed 20 per cent. of the width of the wheel. This point is illustrated in Figs. 6 and 7. No doubt, the smaller the ratio of the steam jet to the width of the wheel, the greater the efficiency, that is, as far as the nozzle and bucket are concerned. Of course, if this width is reduced to an unreasonable degree the rotation losses of the wheel become a larger percentage of the output, and more than offset the increase in efficiency of the nozzle. Therefore, there must be a ratio that will give the best output result, and this has been found to be between 15 and 20 per cent. of the width of the wheel. Of course, as the steam enters and reënters the wheel the steam film is becoming wider because of the fact that its speed is being reduced, but the subsequent impacts in the rotor become less and less effective, and this increase in width is not so detrimental as in the initial jet, as the energy extracted varies as the square of the steam velocity.

It has been found that the steam passes through the rotor in a design of this kind, practically three times. Roughly speaking, the steam gives up 75 per cent. of its energy the first impact, 20 per cent. the second and 5 per cent. the last. This ratio, of course, varies with the rim velocity of the rotor and the initial and terminal steam conditions. While there are four reversing chambers which would be required, because the first reversal would extract a larger percentage of the energy, leaving a small amount to be taken out in the subsequent reversals. While this is true as far as the amount of energy taken out in each reversal is concerned, it does not hold that three reversing chambers will show better efficiency than four at high speeds, as can be seen from

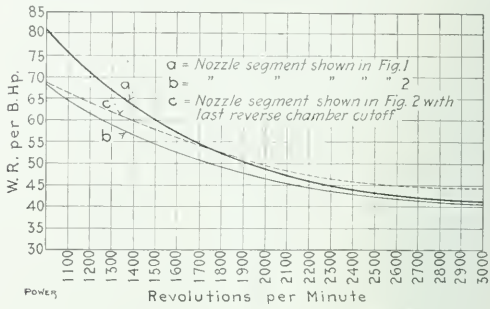


FIG. 3. RELATION OF WATER-RATE AND SPEED

curve *c* above referred to. The explanation of this is probably the fact that at high speed the rotor advances the steam so rapidly that more work is done in the forward chambers than would be at relatively slower rotor speeds.

Another point in favor of nozzle No. 2 is shown in Fig. 8. This shows, in full lines, a development of the rotor, with a development of the initial nozzle and reversing chambers in dotted lines superimposed. It will be seen that it is impossible for any relation to exist between the reversing chambers and rotor whereby there will be

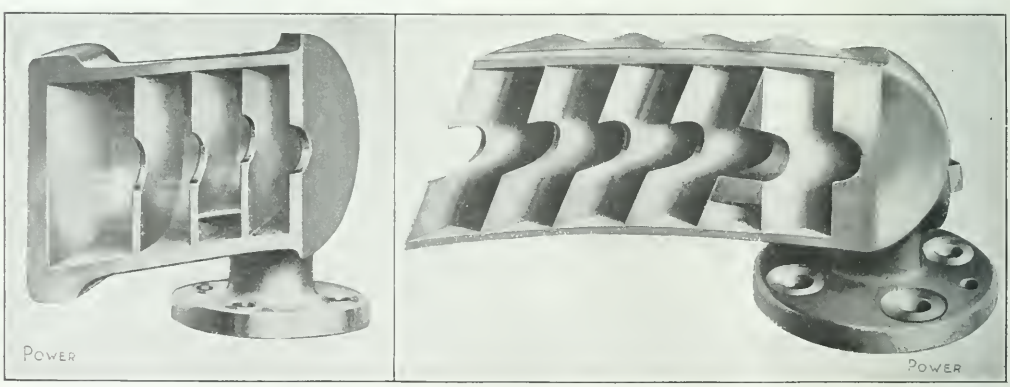


FIG. 1. THE OLD STURTEVANT TURBINE NOZZLE BLOCKS FIG. 2. THE NEW

bers shown in Fig. 2, it does not necessarily hold true that the steam makes four complete reversals, but it has been found by experiment that four chambers, as shown in this design, give the best efficiency under the usual operating conditions. The dotted curve, designated as *c* in Fig. 3, shows the relative effect of nozzle No. 2 with the last of the reversing chambers removed. In other words, this has three diagonal reversing chambers forward of the supplementary chamber and the initial nozzle.

One would naturally think that the higher the rim velocity of the rotor, the fewer the number of reversing no free, unrestricted path available when the steam is traversing the rotor and reversing chamber buckets. In other words, if the rotor were held in a stationary position in any relation whatever to the nozzle, the steam would find an easy exit. This would not be the case with nozzle No. 1, providing the relation existed where the buckets in the rotor exactly coincided with the initial nozzle and the small bucket at its side. That is to say, in nozzle No. 1, at a certain instantaneous relation between stator and rotor, the exit is temporarily closed.

From a manufacturing standpoint, it would at first

appear that nozzle No. 2 would be much more difficult to produce, but a method has been worked out whereby these reversing chambers are machined with a very slight excess in cost over nozzle No. 1. Each reversing chamber is made by two cuts, approximately one-half the width of the bucket, and it is necessary only to square up the corners at the receiving and discharge ends of these chambers.

While at present it is possible to get a slightly higher

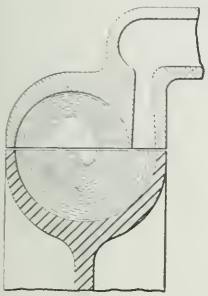


FIG. 4

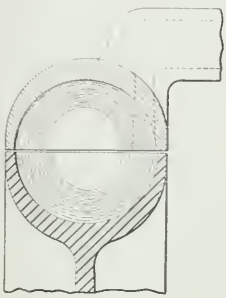


FIG. 5

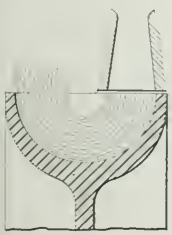


FIG. 6

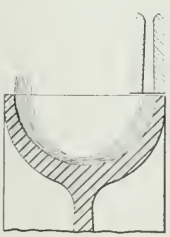


FIG. 7

efficiency with a properly designed multi-stage turbine, it is believed that there are even greater possibilities with a single-stage turbine, than those already achieved. If the economy of a single-stage turbine can closely approximate that of a multi-stage machine, the single-stage turbine will have a decided advantage, not only because of its initial cost, but especially because of its simplicity,

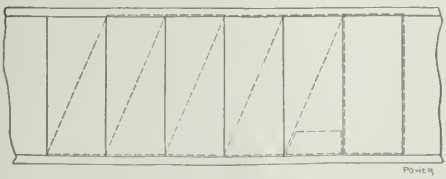


FIG. 8. DEVELOPMENT OF BUCKETS AND SUPERIMPOSED NOZZLE BLOCK

light weight and reduced size. The single-stage turbine is more likely to maintain its original efficiency as there is no tendency for leakage between the stages, while the efficiency of the multi-stage turbine is bound to decrease, due to the increasing leakage around the shaft at the diaphragms. The multi-stage argument that the steam velocity is lower, and the rotor buckets are not so severely subjected to the action of the steam, is true, no doubt, but when constructed of proper material, and using reasonably dry steam, the efficiency of a single-stage turbine can be maintained practically indefinitely.

Future development in the single-stage turbine will probably be confined to the reversing buckets rather than the initial nozzle or rotor, and it is believed that there is greater opportunity for increasing the efficiency of the single-stage than the multi-stage turbine; in other words, the multi-stage has been more perfectly developed to date. Even in its present state of development, however, the single-stage turbine, in small powers, is better adapted for noncondensing work.

Fusible Signal Plugs for Air-Compressor Machinery

The Hodges fusible signal plug which is being placed on the market by the Ingersoll-Rand Co., 11 Broadway, New York City, is devised to give warning of a rise in temperature to a point which has been previously determined upon as the limit of safety. Thus it may guard against the development of excessive strains or other dangerous conditions.

This device consists of a body formed for screwing into a hole tapped for a ¼-in. pipe thread in the wall of the apparatus to be protected, an ornamental cap and a removable stem containing the safety element. The device is neat in appearance and as there are no movable parts, no attention is required by the operating engineer. The material used is mostly brass and copper, and is unaffected by atmospheric conditions.

The plug can be placed in the discharge space of a single-stage compressor, in the high-pressure side of a two-stage compressor, in a receiver or other air container, where, if an excessive rise of temperature occurs, the safety element melts and opens a minute passage through the stem to the head, allowing a small amount of air to pass, producing a distinctive whistle that cannot be overlooked by anyone in the vicinity. This will continue until measures are taken to reduce the primary cause of the threatened trouble. It is then but a moment's work to replace the plug with a new one and the machine is again protected against a similar recurring danger.

These signal plugs are supplied in two types with 350- and 500-deg. F. blowing points, respectively. The 350-deg. plug is suitable for use in the discharge pipe of a single-stage compressor working at 40 lb. gage pressure; in the discharge side of a two-stage compressor working at 100 lb., or in the discharge side of a three- or four-stage compressor, delivering air at 100 lb. The 500-deg. plug is for use in the discharge pipe of a single-stage compressor working at 100 lb. pressure.

Safety on the oil-burning vessels in the Navy will be increased by the provision on such ships, of an oxygen breathing apparatus. It is estimated that about 10 lives are lost each year on these oil-burning vessels, when men are overcome by gases escaping from the liquid fuel. The apparatus is simple, consisting merely of a small oxygen tank, a flexible tube, and a mouth piece covering the nose and mouth, but not hindering the vision as the usual helmet does.—"Engineering News."

The average monthly salaries for engineers in the Swedish merchant marine, states "International Marine Engineering," are: Chief engineer, $81; second engineer, $58; third engineer, $48; fourth engineer, $27; and firemen, $17.

ELECTRICAL DEPARTMENT

Dynamo and Motor Troubles

By R. L. Mossman

The following article explains some of the troubles in the operation of dynamos and motors, giving the causes, symptoms and remedies. It is well in all cases to make a careful examination and not jump at conclusions.

Heating of Bearings

1. Excessive belt tension in which the pulley bearing will probably be hotter than the other. To overcome this, reduce the load or belt tension.

2. Failure of oil rings to revolve with the shaft: oil too low; poor grade of oil; grit in the bearing or a bent shaft. The remedy is obvious.

3. End thrust due to improper leveling or no lateral motion of the shaft—if a belt-driven machine, move the shaft back and forth with a stick pressed against the end of the shaft. The shaft should have a lateral movement of about $\frac{1}{8}$ in. and should float when running. If it does not, it is probably held in one position by the belt, the pulley or the collar. Sometimes the armature projects out more on one side of the field coils than on the other: in this case, the magnetic pull of the field coils will draw the armature in and the pulley or collar may bind against the bearing and cause heating.

4. Unequal air gap—See that the air gap is equal all around the armature, for, if it is nearer one pole-piece than another, the magnetic pull will be unequal.

Heating of Field Magnets

1. Moisture in the coils—This will be indicated by the field circuit testing lower in resistance than normal in that type of machine. In shunt-wound machines, the field would take more current than ordinary. The insulation resistance will also test low. To remedy this condition, the coils should be baked in an oven for several hours, or current may be passed through them: or both means may be used.

2. Excessive current in the field circuit—The symptoms are, the field coils will become too hot to permit holding the hand on them. Their temperature will be over 50 deg. C. above the surrounding air. In the case of a shunt-wound, or separately excited machine, the voltage should be decreased at the terminals of the field coils or the resistance of the coils can be increased by adding more wire or by putting resistance in series. A short-circuit could also cause heating; this would be indicated by the short-circuited coil being cooler than the others.

Heating of Armature

1. Excessive heating in armature coils—In this case reduce the load.

2. Short-circuited armature coils, caused by moisture or defective insulation—Test the coils, and remove the cause; if this be moisture, then dry out as for the field coils.

3. One or more reversed coils in one part of the armature—Test for this with a compass and, if found, reconnect the coil to agree with the others.

4. Heat conveyed from other parts, such as the commutator or bearings—In this event, start the machine cool and notice which parts heat up first.

Heating of Commutator and Brushes

1. Heat spread from other parts of the machine.

2. Sparking—Any of the causes of sparking will cause heating more or less.

3. An overheated commutator will decompose carbon brushes and cover the commutator with a film of carbon, which offers resistance and increases the heat. The commutator and brushes should be cleaned and the brushes fitted to make good contact at the proper points.

4. Bad connections in the brush-holder—For these, test out the connections by the "drop" method for higher resistance than normal and improve the connections.

5. Arcing or short-circuiting between the segments—The symptoms are a burned spot at the point of short-circuit. If this is noticed, pick out the charred particles and repair the commutator.

6. Carbon brushes heated by current—To remedy this, see that the brushes fit the commutator and are properly spaced. Use larger brushes so that the current density does not exceed 30 or 40 amp. per sq.in. of contact area, or use lower resistance brushes

Sparking at Commutator

Sparking is not very objectionable if moderate in amount and duration. Beyond this, however, it is likely to burn and roughen the commutator and cause heating.

1. It is sometimes caused by the armature carrying too much current, due to overload or excessive voltage. If excessive current flows for any length of time, the whole armature becomes heated. An overload, due to friction, may be detected by turning the machine by hand. A convenient and sensitive test for any size of machine is to determine the current required to run the armature free (operating as a motor) which should not be more than 4 or 5 per cent. of the current at the rated load, except in machines of 10 hp. or less, which may take 6 to 10 per cent. The remedy in this case is to reduce the load, reduce the speed of the machine, or decrease the field strength in the case of a dynamo and increase it in a motor.

2. Sparking may also be caused by the brushes not being set at the neutral points. In this case the brushes should be shifted backward and forward until sparking is reduced or eliminated. If the brushes are not set opposite each other, or in a four-pole machine 90 deg. apart, they will spark. To set them, count the commutator segments, or wrap a piece of paper around the commutator and divide it into the same number of equal

parts as there are sets of brushes. Then, set the brushes to the marks on the paper, which will space them equally. The usual position of the brushes is nearly opposite the spaces between the polepieces; but, on some machines, this will not hold good, and it is necessary to give a forward lead (in the direction of rotation) to the brushes in the case of a dynamo and a backward lead in the case of a motor.

3. A commutator may have high bars, flat bars, projecting mica or be rough. If such proves to be the case, the commutator may be made smooth with a fine file or sandpaper. If it is very rough or eccentric, it should be turned off. For turning use a diamond-pointed tool with a very sharp and smooth edge. Take a very fine cut each time to prevent tearing or catching in the copper, which is very tough, and finish with a fine file and sandpaper. Any particles of copper should be carefully removed from between the bars. Use a little oil or vaseline on the commutator, if necessary.

4. The brushes may make poor contact, in which case they should be fitted to the commutator by drawing a piece of sandpaper between them and the latter. See that the brush-holders work freely and that the brushes do not bind in the holders.

5. A short-circuited or reversed coil in the armature may cause sparking. This will cause a motor to draw excessive current even when running free without load,

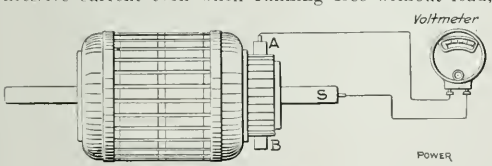


Fig. 1. Testing for Insulation Resistance with Voltmeter

or a generator will require considerable power even without any external load. A reversed field coil can be located with a compass; the coils should be alternately north and south or should alternately attract and repel one end of the compass needle. If a coil proves to be short-circuited, it will burn out under load and should be removed. A reversed coil may be connected properly.

6. An open circuit in the armature will also cause sparking. It is usually indicated by long, heavy flashing, and the commutator bar, or mica, nearest the break is usually badly burned or eaten away. These symptoms might be laid to high bars; but an open circuit can be distinguished by slowly turning the armature when violent flashing will continue. After the break has been located, if a permanent repair cannot be made at once, the sparking can be stopped by connecting together with solder the two bars adjacent to the break; this will cut out the defective coil; but the coil should be repaired permanently as soon as possible.

7. Still another cause of sparking is a grounded armature. Two or more grounds would have practically the same effect as a short-circuit and should be treated the same. A single ground would have little or no effect, provided the circuit is not grounded at some other point. On an electric railway, or other circuit with an earth return or a three-wire system with the neutral grounded, one or more grounds in the armature would allow the current to pass directly through them and would cause the machine to spark. A ground will sometimes be produced by the static electricity from the belt puncturing the insulation, if the frame of the machine is insulated from the ground. If the frame is grounded, this cannot happen. The frame of a machine that is insulated can be grounded through a high resistance, which will carry off the static charge. The remedy for a ground is obvious.

8. A weak magnetic field will be indicated by the polepieces not being strongly magnetic when tested with a piece of iron. The position of least sparking is shifted considerably from normal, due to the relatively strong distorting effect of armature reaction. In a shunt-wound motor, under these conditions, the speed is unusually high; whereas a generator fails to provide full voltage. A reversed field coil will weaken the field magnetism and cause sparking. If the series coil of a compound-wound machine opposes the shunt coil, it will reduce the voltage instead of raising it when the load increases.

Failure to Generate

This is usually due to the inability of a self-exciting dynamo to "build up" its field magnetism. The proper starting of such a machine requires a certain amount of residual magnetism, which must be increased to full strength by the current generated by the machine itself.

1. The residual magnetism may be too weak or destroyed, due to vibration or jar, proximity of another machine or a reversed current through the shunt or series field coils, but not enough to completely reverse the magnetism. If it is completely reversed, the machine will build up a field of opposite polarity. The symptoms are, little or no attraction when the polepieces are tested with a piece of iron. The trouble may be remedied by sending a magnetizing current through the field coils from another machine or battery; if this fails, apply the current in the opposite direction, also the brushes may be shifted backward to make the armature magnetism assist that of the field.

2. Reversed connections of half of the field so that one-half opposes the other will make the generator fail to generate. This may be detected by testing with a compass.

3. Short-circuit in machines: If the short-circuit is in the external circuit, it will prevent the building up of a shunt-wound machine, but will assist a series-wound machine.

4. An open circuit may cause failure to generate, which may be due to a broken wire or faulty connection in the machine, or to poor brush contact.

Testing and Locating Faults

Locating a reversed coil in the armature—Supply a moderate current to each coil in succession by touching the wire to each two adjacent commutator bars and hold a compass over the corresponding coil. The latter will reverse when the reversed coil is reached.

Testing insulation resistance with a voltmeter—This test is made with the machine running. Connect the voltmeter across the brushes A and B (Fig. 1) and note the reading; call this E. Then connect the voltmeter as shown and call this reading E_1. Let R equal the resistance of the voltmeter and X the insulation resistance. Then

$$\frac{E \times R}{E_1} - R = X$$

To test the field coils for a short- or open circuit, connect to the source of current, as in Fig. 2, using lamps to regulate the current. Connect the voltmeter across the coils, as at *AB*, *CD*, *EF* and *GH*. If the voltmeter readings are the same for all coils, the coils are all right, unless they should all be short-circuited, which would be unlikely. If any coil is short-circuited, the reading of the voltmeter will be low. If the coil is open, the voltmeter will show a higher reading. The actual resistance of each coil can be found by connecting an ammeter in

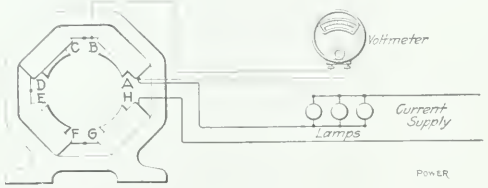


FIG. 2. TESTING FOR SHORT- OR OPEN-CIRCUIT IN FIELD

the circuit. By Ohm's law, the resistance will equal the electromotive force, divided by the current, or $R = E \div I$.

A ground can be located with a magneto or by using a voltmeter or lamps. Fig. 3 shows connections for testing armature coils, for open, partly open or short-circuited coils. Here *A* is a low-reading ammeter, which is adjusted by means of a shunt to give a large deflection when the leads *D* and *E* are short-circuited. The leads are then brought in contact with adjacent segments of the commutator; the deflections being compared with one another to give the comparisons of the resistance. If a coil is open, or the connections broken, the ammeter will give a low reading when spanning its segments. If a coil is partly open, the high resistance

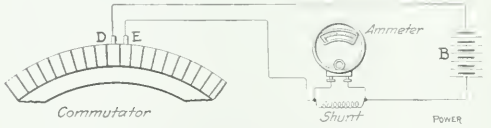


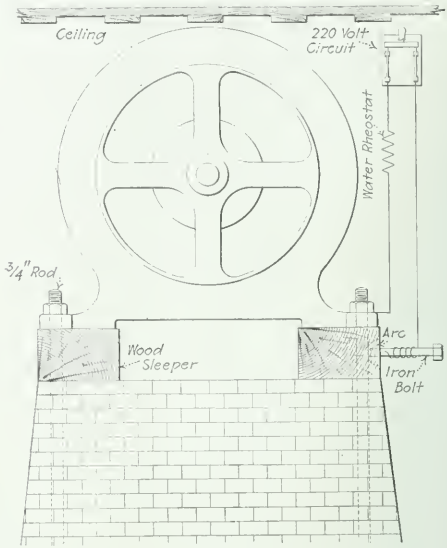
FIG. 3. TESTING ARMATURE FOR SHORT- OR OPEN-CIRCUIT

at fault will give a low reading on the ammeter. A short-circuited coil will show a greater deflection than a good coil.

The temperature rise of the armature and field coils can be measured with a thermometer laid on the part and covered with cotton waste; but such tests do not show the heat within the coil. A better method is to take advantage of the rise of resistance due to the temperature rise. The increase is about 0.004 ohm per deg. C. for each ohm of resistance of the coil.

Removing Foundation Bolts

Some time ago we wished to move one of our motors which was anchored to the brickwork by $\frac{3}{4}$-in. rods as represented in the sketch. There was not room enough to remove the nuts and lift off the motor, because of the ceiling overhead, which had been constructed after the motor was in place. We, therefore, connected one side of a 220-volt circuit through a water rheostat by means of a wire clamped under the nut as shown. A hole was made in the wood sleeper to reach the rod and through this hole contact was made to the rod from the other terminal of the circuit by means of a wire to the end of which a short iron bolt was attached. The arc was struck



SHOWING HOW FOUNDATION BOLTS WERE REMOVED

by breaking the contact. The current was maintained at about 30 amp. for three minutes, when the rod became red hot at that point; then by tightening on the nut and striking the rod a few blows it was severed. This was repeated for each rod, and the motor moved horizontally.

Washington, D. C. CHARLES W. MORTIMER.

Static Charges on Belts

In reference to an inquiry signed J. H. G. on "Avoiding Static Electric Shocks" with your answer to same published in the Mar. 25 issue, I would point out that the grounding of hangers, bearings, etc., is not sufficient to remove all the static electricity from a moving belt. A rather careful investigation of this subject was made by the E. I. duPont deNemours Powder Co. some time ago and it was found that in addition to such grounding, it was advisable, where desirable to remove all the accumulated static charge, to install metal combs on the underside of the belt close to the point where it left the revolving pulleys, and in addition to this to treat the outside surface of the belt periodically with a half-and-half mixture of glycerin and water. The generation of such static electricity seems to be brought about by some internal movement of the particles or fibers of the belt structure, and the static charge appears equally strong along the entire length of the belt and is little affected by increased tension or slipping of the belt.

Since the belt material is usually a nonconductor of electricity, in order to dissipate the charge it is necessary to render it conducting. This is achieved by the use of glycerin and water.

Wilmington, Del. L. A. DEBLOIS.

GAS POWER DEPARTMENT

Some Developments of the Gas Engine

By Everard Brown

The first practicable four-stroke-cycle gas engine was invented about 50 years ago by Otto in Germany. For a long time its manufacture was restricted to small sizes, largely because of the necessity of cooling the exhaust valve which, it was thought, would entail many undesirable complications. To eliminate this, the two-stroke-cycle engine was developed as, in this, the piston acts as an exhaust valve by uncovering ports through which the waste gases escape.

Two-Stroke-Cycle Engines

One of the earliest commercial two-stroke-cycle engines was invented by Dugal Clerk, of London. It had a simple cylinder, was single acting and had a common air and gas pump, independent of the power cylinder. This pump scavenged and charged the cylinder through a main inlet valve when the power piston was at the end of its stroke and the exhaust ports were uncovered. No attempt was made to build this engine in larger sizes, although a number of the small sizes were put into use. Its manufacture was finally abandoned, because it was found to be more expensive to build than the Otto four-stroke-cycle engine.

About this time Oechelhäuser, of Berlin, invented a two-stroke-cycle gas engine that came into considerable prominence. This engine consisted of a cylinder with both ends open and had two pistons, each of which worked at one end of the cylinder in opposite directions and were connected to what might be called a common three-throw crankshaft. One piston uncovered a row of inlet ports through which the gas and air were admitted while the other simultaneously uncovered a row of exhaust ports through which the waste gases escaped. During the interval that the pistons were in these extreme positions the cylinder was scavenged of the waste gases and charged with fresh air and gas by independent pumps. Then as the pistons approached each other the charge was compressed at the middle of the cylinder and then ignited. This engine had the distinct advantage in that there were no valves exposed to high temperatures and pressures, for one piston acted as the inlet valve while the other acted as the exhaust valve. The development of this type was a long step forward as it eliminated all the valve-gear troubles heretofore incident to gas-engine operation. It was not long, therefore, before larger units were built; in fact, many of the leading manufacturers abroad are still building this type, with slight modifications,* in sizes ranging from 500 to 1500 hp. for operating rolling mills, electric generators and blowing engines.

This type has certain disadvantages, however. For example, the power required by the independent scavenging and charging pump ranges from 8 to 10 per cent. of the total power developed. Furthermore, as it is essentially a single-acting engine, it produces but one impulse per revolution, which necessitates a large flywheel and also makes the cost per horsepower high. Another disadvantage is that the power must be taken off at the three-throw crankshaft in order to balance the stresses. In fact, the shaft has been known to fail in some instances where the forces have not been properly balanced because of attaching the blowing-engine cylinder direct to one of the pistons. To offset this disadvantage, however, this engine has no valve-gear with its attending complications.

The next two-stroke-cycle engine of prominence was that invented by Koerting. There is a good example of this type on a large scale at the Lackawanna Steel Co.'s plant in Buffalo. As originally brought out, this engine was single acting and was similar to that invented by Clerk, the principal material difference being that the air and gas pumps were separate, thus giving better control of the mixture. Also, the Koerting engine had an ingenious system of piping between the pumps and the main inlet port of the cylinder, admitting a quantity of air in advance of the mixture to scavenge the waste gas. By this arrangement the mixture could also be stratified for reduced loads.

Later, this engine was made double acting, the power cylinder having a row of exhaust ports in the center that are exposed by the piston when it is at either end of the stroke. At each end of the cylinder there is a main inlet valve through which the charge is admitted simultaneously with the exposure of the center exhaust ports by the piston.

Among the criticisms that may be advanced against the Koerting engine is the location of the valves in the head. In order to examine or remove the piston it is necessary to break the air and gas connections and remove the valve-gear. Another objection is that the power consumption of the air and gas pumps is said to be from 10 to 15 per cent. of the total power generated by the engine. Furthermore, the interval of time when the piston is at the end of its stroke, during which the cylinder must be scavenged and charged, is very short; therefore, the main inlet valve must be large and must operate through a considerable distance in order to admit sufficient mixture in the short interval allowed. As compared with a four-stroke-cycle engine the valve must open and close in one-quarter the time. In addition to this it must travel through a greater distance. Some of these objections have now been overcome to a certain extent. However, a feature to commend this type is the absence of exhaust valves as compared with the double-acting, four-stroke-cycle engine. Whether the troubles incident to such valves are sufficiently serious to offset the objections mentioned as relating to the two-cycle engine is a question for debate.

Four-Stroke-Cycle Engines

During this development of the two-stroke-cycle type, the four-stroke-cycle principle was by no means aban-

*The Junkers engine.

doned. On the contrary, it received probably as much attention from some of the leading European builders as did its competitor, consequently the development of both types progressed simultaneously. The manufacturers largely responsible for the development of the four-stroke-cycle engine are: The Otto Gas Engine Co., of Cologne, the John Cockerill Co., of Liége, the Nürnberg Engine Co., of Nürnberg, and the Premier Engine Co., of Nottingham, Eng. Germany, however, deserves more credit for the advancement of the gas engine than all the other countries combined.

Until a few years ago the four-stroke-cycle engine was built as a single-cylinder, single-acting unit in which the piston was exposed to air circulation and, therefore, did not require water cooling. Probably one reason for this was the belief that cooling the piston by means of circulating water would materially reduce the engine efficiency. Also, it was thought impracticable to build a stuffing-box for the piston rod that would withstand the heat. A little later the design was changed to a tandem two-cylinder construction but still single acting. Subsequent investigations proved that water cooling of the piston did not materially affect the economy and as a result the double-acting, tandem two-cylinder construction was made possible. The development of metal rings for packing the piston-rod stuffing-box also hastened the adoption of this newer type. Both of these developments gave a great impetus to the four-stroke-cycle engine as it practically put it on the same basis with the Koerting two-cycle engine as regards regulation and cost per horsepower with the advantage of having greater mechanical efficiency. This form of construction was developed only about 15 years ago.

At first almost all of the leading manufacturers located the valves in the heads of the engine cylinder which, obviously, was an objectionable feature. The next important step, therefore, was the placing of these valves in the cylinder body. This left the heads free for removal when necessary for the examination of the piston and the interior of the cylinder. This form of construction—tandem, two-cylinder, double-acting and four-stroke-cycle, with the valves located on the cylinder body—has now been so generally adopted that it is looked upon largely as the standard practice. Subsequent improvements have been of minor importance relating mostly to details of regulation, valve-gear and cylinder construction.

As the higher thermal efficiency of the gas engine over the steam engine has been well known for the past 30 years, at least, it is surprising that the latter has not been supplanted. The apparent hesitancy to do this can, no doubt, be largely attributed to the various mechanical difficulties encountered in the development of the modern gas engine which had to be surmounted step by step. Furthermore, the delay in taking it up more generally in the past was also due to the lack of a satisfactory gas producer to supply the fuel. For a long time blast-furnace gas, because of its low thermal value, was considered wholly unsuitable for this purpose. Moreover, the dust in such gas was an obstacle against its use so that in a way the advancement of the gas engine was further retarded until suitable gas-washing apparatus could be invented.

The John Cockerill Co., of Liége, Belgium, probably made the first installation to demonstrate the practicability of using blast-furnace gas in a gas engine. This installation was made at the furnaces at Seraing and consisted of a single-acting, single-cylinder unit of 300 hp. The gas as it came from the furnaces contained only a small amount of dust, and it was not thought necessary to wash it.

The next installation, made by the same company, was at Differdingen and consisted of nine single-acting, single-cylinder engines of 600 hp. each. Both of these installations gave considerable trouble, due largely to the dust in the gas which cut the cylinders and pistons badly. These troubles finally drove the Differdingen firm to the development of a gas washer and, after several costly experiments, they found a centrifugal fan with a spray of water played into it to be the most satisfactory.

Later the installation at Seraing was succeeded by a single-acting, tandem, two-cylinder engine of 750 hp. at which time a Theisen gas washer was also installed. The installation of this unit and the experience gained from it led to the later development of the double-acting, tandem, two-cylinder engine and from that to the modern twin-tandem, double-acting, four-stroke-cycle machine.

During this time the only other builder of the four-stroke-cycle type, in large sizes, was the Nürnberg Co., which seemingly kept pace with the Cockerill Co. At the same time, however, the Otto Gas Engine Co. was developing an engine practically along the same lines but in the smaller sizes only. This company apparently was rather conservative, although it adopted the double-acting, tandem type almost at the same time that the Cockerill and Nürnberg companies did, all three working on the four-stroke-cycle principle.

There are, of course, many builders of large and small gas engines in Europe, other than those mentioned, but the majority are either licensees of these companies or have adopted their general design but are exploiting some special features such, for example, as the Crossley engine of England. This is practically a single-acting, four-stroke-cycle engine of the Otto type, except that it has a balanced exhaust valve.

Another form of the Otto four-stroke-cycle engine was invented by a Mr. Lateme, of Paris, which for a time was favorably considered and which received first prize at the Paris Exposition in 1900. The distinguishing feature in this engine was that it had a greater compression for the light loads than for the heavy loads, thus giving better combustion under reduced load conditions. There were, however, certain objections and disadvantages which prevented its general adoption. Still another form of this same Otto four-stroke-cycle engine was the Premier, built near Nottingham, Eng. The special feature of this engine consisted of a small auxiliary air pump intended to scavenge the waste gases from the clearance space before admitting the charge. This was done by opening the inlet valve on the exhaust stroke a little in advance of the closing of the exhaust valve so that the air, under pressure in the receiver between the inlet valve and the air pump, rushed in and scavenged the waste gases and cooled the surfaces of the cylinder head and piston, thereby increasing the capacity and efficiency of the engine.

Development in America

In this country the development of the gas engine has not been carried on as aggressively as in England and

Germany. While we have many builders of gas engines in the smaller sizes, it is only within recent years that the large units have received much attention. For example, the Westinghouse Machine Co. has built gas engines up to 200 and 300 hp. for some years but only within the past few years has it put out the larger-sized machines. This company now has some large engines in operation, including blowing engines, all of which are of the double-acting, tandem, four-stroke-cycle type.

The Snow Steam Pump Co. probably deserves the credit of being the first American concern to build successfully large modern gas engines. The design adopted is the tandem, double-acting, four-stroke cycle with the valves on the cylinder body at the side and placed in a chamber. In the last respect only does it differ from the standard modern type of engine. This company has built and has in successful operation units as large as 5000 hp.

Among other manufacturers are the Allis-Chalmers Co., which is the licensee of the Nürnberg engine, of which a number of large sizes have been built, and the De La Vergne Co., of New York City, which builds the Koerting two-stroke-cycle and four-stroke-cycle engines. Practically all of the other and smaller builders have adopted the standard tandem, double-acting, four-stroke-cycle design with the valves on the cylinder body, the inlet on top and the exhaust underneath.

In the earliest types of gas engines the charge was ignited at atmospheric pressure only; that is, there was no compression. About 1860, however, it was discovered by experiment that by compressing the charge before ignition a greater efficiency as well as capacity could be obtained. The result is that today all modern engines compress the charge from 100 to 150 lb. per sq.in. before ignition, the amount of compression depending largely upon the gas.

In the same way has the governing arrangement been improved upon. Formerly the engines were controlled by the hit-and-miss method of regulation: that is, at full load the engine exploded a full charge at every cycle, but as the load was reduced, the power stroke would be omitted now and then by the governor not admitting any gas. This was probably the most efficient form of governing from the standpoint of economy, but it gave poor regulation and necessitated large flywheels; consequently the later designs are so arranged that the amount of the effective charge is lessened for reduced loads. This may be done in several ways, one of which is to change the quality of the mixture by throttling the gas only. The objection to this method of governing is that the mixture may become so lean on light loads as to impair its ignition.

Another method of regulation is by throttling the quantity of the mixture and leaving the proportions of air to gas constant. To maintain a mixture of constant proportions for all loads is very desirable yet, on the other hand, this plan has a tendency to reduce the compression on the light loads and thus cause poor combustion. To overcome the objections to both of these methods, various combinations and forms of stratification have been resorted to; these involve a somewhat more complicated mechanism. As to which is the best method, is a matter of opinion, and there is undoubtedly room for further improvement in this particular phase of gas-engine design.

CORRESPONDENCE

Gas Engine Cylinder Lubrication

L. L. Brewster, in the Mar. 11 issue, seems to have overlooked some points in his criticism of A. L. Brennan's article on "Gas Engine Cylinder Lubrication." Mr. Brennan says: "The first indications in the case of using a poor oil are manifest in decreased power, due primarily to the friction offered the surfaces of the piston and cylinder; secondly, to faulty compression, due to the piston rings becoming inoperative, and, thirdly, to carbon deposits, which materially reduce the efficiency of the valves and impair the function of the spark plugs." To this Mr. Brewster replies: "I have yet to see one (an engine) in which I could discover a case of improper cylinder lubrication by a decrease in the power developed."

I would say that Mr. Brennan is right, except, perhaps, in a very few instances. In my experience, covering a period of nine years, with almost all makes of gas and oil engines, ranging from 65 to 500 hp., I have found that improper lubrication of the cylinder will cause a decrease in the power developed. For instance, in using an oil with a heavy body and of a low fire test, one is apt to get a large amount of carbon. This will cause the engine to miss fire by accumulating on the spark plugs. Also, carbon and burned oil will deposit around the valve seats, preventing the valves from seating properly, and there will be a loss of compression through the exhaust or the engine is apt to backfire through the intake. This will, as a rule, cause a decrease in power; in fact, I have known it in certain cases actually to stop the engine.

In using an oil that is too thin, one is apt to have trouble with the engine heating up. This, as a rule, causes the engine to slow down, and the power to decrease. Furthermore, the excessive heat may thin the oil until it is not sufficient to keep the piston from rubbing the cylinder walls, and it is liable to score them; as a result the piston may seize.

In an engine with a badly worn cylinder and rings the thin oil will blow out and the cylinder will not get its surface covered enough to properly lubricate it, nor to hold compression. This will cause perceptible loss of power. I have had the oil gum so that it was almost like tar; and it would retard the action of the piston to such an extent as to cause the engine to slow down and gradually stop. In most instances this can be prevented by a careful engineer through attention to the lubricator or by a quick change of oil. Of course, conditions vary in the different engine rooms, so it is hard to tell just what can be done. But I have, several times, saved a shutdown on account of poor oil, by getting busy as soon as the engine began to show any symptoms of defective oiling.

L. T. Durman.

Geddes, S. D.

Dugald Clerk, says "The Mechanical Engineer," has recently devised a scheme to prevent preignitions in gas engines using coke-oven gas, which is high in hydrogen, by introducing cooled exhaust gases into the inlet pipe and thus diluting the gas. It is claimed that this does not materially decrease the power of the engine.

HEATING AND VENTILATION

Some Troubles of Steam Heating Systems

By Charles H. Bromley

Drawing the air from steam-heating systems by means of a vacuum pump aids in the operation of the plant, and where insufficient radiation has been provided it often makes it possible to maintain comfortable temperatures in the rooms during periods when the load on the engines and other steam-consuming units is normal. During periods of low load or very low temperatures, the exhaust is usually inadequate and the addition of live steam is required.

At night when the engines are shut down, it is common practice to supply live steam at boiler pressure through a large live-steam line from the header direct into the main exhaust or trunk line of the heating system. Where the system is compact and the boilers are centrally located, this one large connection will prove satisfactory. But where the system is distributed over a wide area, and especially in buildings of the usual skyscraper height, say eight or more stories, the one connection is not wholly satisfactory.

In most office buildings the load drops considerably just at the time the outside temperature is falling. Almost immediately the pressure in the heating system drops to a vacuum and the valve in the live-steam connection must be opened more and more as the load and temperature continue to fall. To fill a large system quickly from one source of supply entails exceedingly hard work on the part of the fireman as the steam is condensed long before it gets to the extreme ends of the system. This condition is so bad in some plants that firing the boilers on the night watches is almost unbearable.

To obviate such troubles and to secure good regulation of the system, two live-steam lines of 1 to 2½ in. diameter each, depending upon the arrangement of the heating system, should be connected to the branch mains at the extreme ends of the system.

Vacuum Troubles

The air-relief valves are the greatest source of trouble. Everyone is familiar with the manner of adjusting these valves, but because it is a simple operation, many are too careless in adjusting them properly. In most cases they are not adjusted close enough, so that steam is constantly being blown into the vacuum lines. This disintegrates the valve pencil or so coats it with dirt as to close the valve tight, and when a screwdriver is applied to open it, the valve is frequently stuck fast. If too much force is used in trying to back off on the pencil, the brass cap unscrews, leaving the pencil stuck in the valve. When this happens the quickest way to remove it is to take off the valve and, holding it in a pair of gas pliers, drill out the pencil, being careful not to drill into the valve seat.

Plugged Vacuum Lines

It is chiefly because the air valves are not adjusted close enough that troubles from plugged and corroded vacuum lines are experienced. The first step is to locate the obstruction, which may be done by trying for vacuum on the floors above and below the radiators affected. The seat of the trouble, if in the local line or the riser, may be readily located, and if in the former, disconnect the short pipe between the air valve and the elbow or tee, for the trouble is likely to be here, and in this event the obstruction can be quickly and easily removed.

If the riser is plugged so badly that there is insufficient vacuum, the line must be washed out by using a hydraulic force pump. Locate the riser in the basement and make provision for a nipple and hose connection to it, even sawing the line if necessary. This is a disagreeable job at best, for it is often necessary to lie cramped over hot pipes and sometimes there is only room to use the blade of the saw.

Pails of water and hose lengths for connecting to the suction and discharge sides of the pump should now be obtained. The hose on the discharge side should be of good quality and able to withstand high pressures. Connect the discharge hose to the riser and somewhere above the obstruction open the line, i.e., disconnect it at a radiator (one in a toilet is preferable), attach a piece of hose and have pails ready to catch the water as it is pumped up through the line by the men operating the force pump. Hot water is best as it softens the matter in the pipe.

There should be plenty of leverage on the force pump so as to facilitate pumping under high pressures. It is well to connect a pressure gage to the pump to eliminate guesswork as to the pressure applied. When high pressures have been repeatedly put on the line from below and above the obstruction and the latter is not removed, the line must be taken apart to be cleared.

Air Bound Coils

In indirect systems using four or five large manifold coils for tempering and heating the air, trouble is sometimes experienced on account of the coil not heating throughout. This allows large volumes of cold air to pass through the coil and on into the rooms. This condition is sometimes so bad that, where air-washing systems are used, the water from the spray pipes freezes, forming large icicles, and iced air is passed into the rooms. The trouble is due chiefly to the vacuum pipe being plugged or too small so that air remains in the coils, to the coil return being full of water or to a shortage of steam. It can be eliminated by putting a tee in the vacuum line and connecting a branch to the front part of the return header as at *A* in Fig. 1, in which *B* is a sheet-iron filler box and *C* is the doorway to the housing.

Adjusting Thermostat

When the coils are thermostatically controlled, as they usually are, and icicles form in the air-washer hous-

ing, the thermostat regulator should be thrown over to the "warmer" side, and left there. This will allow steam to flow through the coils continually and quickly melt the ice. If the main air intake duct contains a door or slide opening between the outside inlet and the air washer, it should be opened to allow the warm air of the basement or room to be drawn in. This will greatly aid in melting the ice. If there is no such opening in the inlet duct one should be provided. The door to the air-washer housing should also be opened at such times, the aim being to pass warm instead of cold air to the coils and washer.

Air and Diaphragm Troubles

Hot air is sometimes passed into the rooms for too long a period and the heat becomes unbearable. When

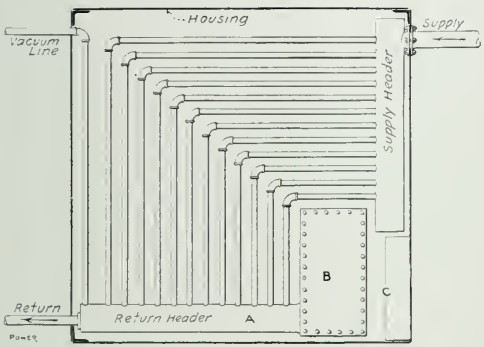


Fig. 1. Heating Coil in Housing

this trouble is general throughout the system it indicates that the pressure of the compressed-air supply to the thermostats and diaphragm valves has fallen, or perhaps the air pump has stopped. When the trouble is confined to only one coil it denotes that the diaphragm *D*, Fig. 2, is leaking, so that the spring *E* holds the valve open. It is then necessary to regulate the steam and temperature by hand while putting in a new diaphragm, a number of which should be kept on hand.

Where the plant uses high-pressure air for water lifts or other purposes, it is best to let the small low-pressure air pumps for the thermostat air supply lay idle and take air for this purpose from the high-pressure receiver through a reducing valve. The air pressure for the thermostats should be 15 lb. per sq.in.

Thermostats

Perhaps most thermostatic troubles are due to meddlers who must "see how it works," and these meddlers are usually men of the engine-room force. One man should have charge of these devices and no others should meddle with them. It is a tedious job to properly adjust a thermostat and to have the adjustments frequently disturbed should not be tolerated.

The chief point about the operation of thermostats is to keep the air supply to them dry and clean, so that the small openings at the needle valves and also the cotton filter will not become plugged. The joints (those having lead gaskets are best) should be kept tight, as small leaks prevent fine adjustment. In justice to the thermostat let it be understood that with proper care it can be made to operate on half a degree temperature variation.

Where thermostats control the steam supply to large coils, the device should be made to operate at a temperature about seven degrees higher than is desired in the rooms. The reason for this is that the coils do not get hot for some time after the steam valve has opened, and by the time the coils have become heated, the room temperature will have dropped considerably below that desired. When the thermostat operates the valve at about seven degrees higher than the desired room temperature, the heat reaches the rooms just before the temperature therein has reached the lowest desirable point. As the thermostat operates in advance of the room-temperature extremes, it will have closed the steam valve before the room temperature is as high as it should be. But the coils at this time contain enough heat to raise the temperature to the desired degree, and the fan will continue to blow this heat into the rooms. By being careful in making the adjustments, and if the rooms are also provided with thermostatically controlled direct radiators, as they should be, the room temperature can be kept almost constant.

Making People Warm without Heat

The most common error in steam-heating installations is that not enough radiation is provided to make the rooms warm enough in severe weather. During these cold

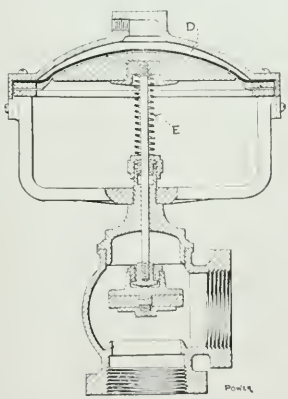


Fig. 2. Diaphragm Valve

intervals the system is carrying as much pressure as it can safely withstand and all radiators are as hot as it is possible to make them. Nevertheless, demands for more heat keep the telephone busy. The man at the 'phone must be courteous and assure the complainants that more heat will be forthcoming and if possible call immediately at the rooms from which the complaints are received, as immediate attention in a case of this kind goes a long way.

Monday morning gives the most trouble, due to dropping the temperature over Sunday and then trying to raise it at the last moment. In rooms where many girls, whose work requires them to sit at desks or do little physical exercise, are employed, one thin-blooded person, by putting on her coat, will make every girl in the room shiver with cold. Complaints will come in and the wise heating man, when he enters the room in response will

agree with the occupants that it is uncomfortably cold, and proceed to inspect every radiator, suggesting to each girl as he goes along that if she gets too warm she may shut off the radiator. On leaving, he should assure the lady in charge that more steam will be turned on and the room made very comfortable in half an hour. In the meantime other complaints must be attended to and that room forgotten, as more heat cannot be sent to it when the system is working at its greatest capacity.

When he returns he should smilingly remark how comfortable the room is, and then (this is the important part) talk heat to the lady-in-charge until she takes off her coat. She will do it, and when she does, one by one each girl will take off hers and all will become warm as quickly as they became cold.

Of course, the above is a poor way to supply heat, but it is the best substitute for radiators and must be applied until they can be installed, which should be as soon as possible.

A New Hot-Water Heating System

Notwithstanding its acknowledged advantages, heating by hot water is often considered impracticable on account of the initial expense by reason of the larger piping required when the gravity system is used, and the impracticability of the forced-circulation system for small installations. Attempts have been made to increase the circulation by applying heat to the risers, but this has proved impracticable on account of the impossibility of regulation from a central point and the high fuel expense.

Herr Herman Kraus, engineer of the German Museum in Munich, has conceived the idea of increasing the circulation by injecting air into the risers, the air subsequently escaping through the expansion tank. The air for a large installation can be compressed by a small motor-driven compressor at the expense of a few cents per day. When compressed air is already available the advantages are all the more manifest. This system permits the use of small piping, is controllable from a central point, and will recommend itself for many installations on account of its simplicity.

Coal Required for Heating

By W. L. Durand

The coal consumption of a low-pressure heating apparatus is often desired at the time of designing the system and may easily be ascertained to a close degree of accuracy by the following method.

Pea coal, which is the size in most common use, contains about 12,000 B.t.u. per lb. Not over 8000 B.t.u. is absorbed by the boiler and with a 10 per cent. loss in the heating system the heat delivered at the radiator per pound of coal is about 7200 B.t.u.

Each square foot of direct steam radiation requires 250 B.t.u. per hr. for zero weather. For New York City about 45 per cent. of this maximum will be required for the heating season of 210 days. In other localities this factor will be different and may be determined by taking the ratio of 70 minus the average temperature of the heating season to 70.

$$250 \times 24 \times 210 \times 0.45 = 567{,}000 \text{ B.t.u.}$$

$$\frac{567{,}000}{7200} = 78.75 \text{ lb.}$$

or practically 80 lb. of coal per square foot per season.

There are various rules for determining the coal consumption, but they are all open to objections and do not give accurate results. The following apply to New York City:

1. *Grate area multiplied by 4.4 equals tons of coal burned per season.*

2. *Each cubic foot of contents will require 0.9 pound of coal per heating season.*

3. $$\frac{\text{Exposed wall surface}}{4.5} + 2 \times \text{glass surface} \over 100$$
$$= \text{tons of coal per heating season}$$

The first rule is practically of no value since the rate of burning coal per square foot of grate surface may easily vary by 100 per cent.

The second is only approximate as the ratio of heating surface to volume may vary anywhere from 60 to 1 to 100 to 1.

The third is probably the most accurate of all as it is based on the heat losses from the walls with an allowance for air change, but would be in error as the ratio of the exposed surface to the volume is far from being a constant.

The method outlined at the beginning should be more accurate, for the heat required per season is first determined and then the coal necessary to supply this heat. This figure of 80 lb. per sq.ft. of heating surface may vary where other coal is used or the efficiency of the boiler differs, but the method is the same and if the proper factors for any particular case are used the estimated and actual coal consumed will be found to be very close.

Heating Building with Waste Heat from Gas Engine

A simple expedient for use at the plant of the Ford Motor Co., Detroit, Mich., has been designed by Edward Gray, for taking advantage of the waste heat of the exhaust gases and the jacket water. This is done by the use of tubular heaters. The jacket water from the engine is circulated by a pump through the heater and back through the engine jacket, giving up its heat through the tubes to the water in the heating system. After leaving this heater the water for the heating system may be passed through a second heater, to which heat is supplied by the exhaust from the engine.

The pressure in the primary heater is on one side that due to the static head existing in the heating system. The jacket water circulated is under a pressure due only to the head necessary to circulate the water, and this may be very small. The primary heater may be of simple construction; in fact, one of the several standard forms of feed-water heaters will serve the purpose very nicely.

The secondary heater, through which the exhaust gases pass, should be constructed of such material as will withstand the possible corrosive action of the exhaust gases, and should, preferably, be of cast iron.

New York City. L. L. Brewster.

EDITORIALS

Boiler Joints

An abstract of an interesting paper, describing tests made to determine the maximum fiber strains produced in the shell plates of boilers in the vicinity of lap joints, will be found on page 518 of this issue. It has been suggested in these columns before, that it would be a step in the right direction if some of our states having boiler laws would devote a small part of the large sums expended directly and indirectly in the enactment and enforcement of boiler legislation to a scientific investigation of the causes of boiler failures of the more common kind.

The lap-joint crack may be safely said to be one of the most, if not the most, prominent causes of disastrous boiler explosions.

While it has been contended for many years that the lap-joint crack is produced by a repeated deformation of the joint, due to changes of pressure (and this is doubtless a correct statement of fact) it has remained for some progressive engineers in far-away Australia to actually demonstrate the intensity of the surface stresses that may be produced in the plate by this means with lap joints.

These tests were undertaken and carried out without government aid, so far as we are aware. They were evidently conducted in the most painstaking manner, and the results obtained are remarkable in their agreement with the theoretical analysis that may be made respecting the maximum stresses to be expected in the plate adjacent to a lap-riveted joint, but it is evident that only the surface of the subject has been touched.

A few years ago the lap joint alone was commonly believed likely to develop defects of this character, but more recent experiences have shown that the butt joint is by no means immune. There have been numerous instances of similar failures in butt-joint boilers throughout the United States during the last few years, but fortunately, to the best of our knowledge, none has resulted in an explosion.

On Aug. 9 of last year, a Scotch boiler on the steamship "Guttenberg" exploded at Rotterdam, Germany, with great violence. This boiler was constructed with a butt joint, and the initial failure was through a crack along the outer row of rivets, which exhibited all the characteristics of the so called "lap-joint crack."

As long as cracks tend to form with this type of joint, it will only be a question of time before other serious explosions are recorded, due to this cause. It would seem that the proper state authorities might take up the work so admirably commenced by these engineers, and demonstrate conclusively why boiler joints of both types tend to crack. Massachusetts boiler laws have done much good by partly prohibiting the use of lap joints, but much remains to be accomplished.

Only the knowledge of how accidents occur can indicate the measures to be adopted to prevent their recurrance. Let us obtain this knowledge with respect to boiler joints before making further rules.

A Municipal Power-Cost Investigation

The year's test which is now being conducted on the plant of the Hall of Records will go a long way toward settling the controversy as to whether it is more economical for New York City to operate isolated plants in its public buildings or to purchase central station current.

This test is the consummation of an investigation begun about two years ago by the Bureau of Municipal Research into the shutting down of several well-equipped city plants and the substitution of central station service. This investigation had the active support of Borough President McAneny.

In this work the Bureau of Municipal Research made a study of the cost of heat and power in a large number of private plants throughout the city and compiled a very comprehensive report. This, however, was attacked by the central station advocates on the ground that certain assumptions had been made in regard to exhaust steam heating.

About this time the question of power for the new municipal building came up. Its proximity to the Hall of Records, the available space in that building, and the fact that its plant was not working up to full capacity, afforded an excellent opportunity for a central plant supplying both buildings by adding to the existing equipment. This plan was strongly advocated by the engineering staff of President McAneny's department. Naturally it met strong opposition from the other side.

It was finally decided to make a year's test of the Hall of Records plant, which would include the loads at all seasons. The test is under the personal direction of Professor Diederichs of Cornell University and the results will be submitted to a board of six supervising engineers; two representing the Bureau of Municipal Research; two the City and two the New York Edison Co.

The outcome of the test is of vital importance to the operating engineers as well as to the city; for should it be adverse to the isolated plant it would affect the positions of many employed in city plants.

⁂

The Flood

It is good to be able to say that the flood disasters in the Middle West are not so serious as at first reported. While the loss of life will undoubtedly be in the hundreds, it is far below the early estimates. In Ohio and Indiana, the public utilities, factories and agricultural interests have suffered the most damage.

Too much cannot be said in praise of the manufacturing and supply people and the operating companies of other sections, for without their quick assistance many power stations would still be helpless.

The loyalty and heroism of the managers and operatives in the flooded districts preserved many public utilities from irreparable loss. This devotion to duty is all the more praiseworthy as many of these men were not only in grave danger while sticking to their posts, but they

were ignorant of the safety of their families and homes, and still they toiled bravely on.

In one Indiana lighting plant the water rose to within an inch of the fire-doors, the pump and condenser pits were filled, and, says the press report, "in spite of all this the plant gave continuous service throughout the perilous period." Many of the men worked sixty and seventy hours so that their townsmen and the industrial interests would not suffer a greater than water damage, and the cities and towns officials are most outspoken in their admiration of the steadfastness of these men who, under normal conditions, are seldom given any public recognition.

The optimism and resourcefulness of the people of the Middle West can do much, but their task of rehabilitation would be far more difficult if outside assistance had not come from other sections. POWER's cartoon on page 515, "Answering the Call of Industrial Distress," portrays, we believe, a vivid picture of that army of eager industrial soldiers which marched to the relief of the storm-stricken cities.

We are a hopeful, open-hearted nation, and in the hour of need we stand ready to give of our time, our skill and our money, feeling that our well-doing is sufficient compensation therefor.

⁂

Water-Power Development by New York State

Whether New York is to commit itself to a policy of state ownership and operation of power plants is now a bone of contention at Albany. The Murtaugh bill now before the legislature provides for the appropriation of six hundred and thirty-five thousand dollars for the construction of hydro-electric plants at the new barge-canal dams in the Mohawk River at Crescent and Vischers Ferry, the power to be transmitted to Albany, Troy, Cohoes and several adjacent towns.

According to the engineers of the Conservation Commission who have carefully studied the problem, it will be possible to develop three thousand horsepower continuously at each dam, and with suitable pondage facilities six thousand horsepower could be produced at each place (a total of twelve thousand horsepower) for use during the hours of peak load, for every day in the year. Moreover, the flow is said to be such as to make available power considerably in excess of this during ten months of the year, and with an auxiliary steam plant to help out during the dry season the capacity could be greatly increased.

As would be expected, the large private power interests are actively opposing the passage of the bill. Through a committee of the National Electric Light Association, of which Arthur Williams is chairman, they have protested before the legislature in an effort to show that the figures of the Conservation Commission's engineers are incorrect, that the available flow would not warrant the installation of a hydro-electric plant, and that the state would be the loser.

This might be mistaken for a splendid example of public spiritedness were it not for the fact that the same committee recommends, as a substitute, legislation permitting the sale of this and other state water powers at *public auction* to private interests. Surely if the flow is not such as to warrant state development we fail to see how, except by a miracle, it could be increased under private exploitation.

As to the expediency of state or municipal ownership of power plants, opinion is divided. Many claim that it is impossible to keep such undertakings free from political influenes, yet in Europe and in certain cities in the West and South we have excellent examples of what can be accomplished through efficient municipal operation.

Again, some contend that a public-utility corporation operating under franchise in a certain locality and in compliance with local regulations should be protected against competition. This is reasonable so long as the company continues to give adequate service at reasonable rates and does not attempt discrimination. The people should retain the right, however, to step in with their own plant just as soon as any of these provisions are violated. While it might not always be advisable to exercise this prerogative, it would serve as a powerful weapon in the hands of the people to guard against breach of faith on the part of public-utility corporations.

⁂

In Denver, Colo., the Citizens' Protective League has been organized "to elevate the tone and moral standards of the newspapers of Colorado."

Denver is some distance from our easy chair and we are not familiar with the "vicious journalism" that brought this league into existence. We can well imagine, however, that the conditions were unbearable, for only then can the public be aroused to action. If public sentiment could only be stirred up in behalf of legislation in our different states respecting boiler inspection and engineers' licensing, what a big thing it would be for safety to life and property.

⁂

While it cites an exaggerated instance of incompetency, the letter on page 537, "Example of Poor Engineering," by analogy, is an argument for licensing engineers and inspecting boilers. Evidently state legislation might even be extended to cover hot-house installations. At any rate the experience should serve as a warning to anyone putting in a steam plant of any kind that it is economy in the long run to employ qualified designers and contractors.

⁂

The story is told of an engineer who complained that recent shipments of coal received were not near as good as previous shipments. He insisted on an explanation and the coal dealer informed him as follows:

"Most of my customers up your way purchase their coal on a heat-value basis and, of course, they rejected their last lot, so I had to send it to you, who I knew purchased without testing."

⁂

The English author of the article on "Some Notable Boiler Explosions," in our issue of Dec. 10, evidently had not read the entire story of the water-tube boiler explosion at St. Louis some years ago. It was shown in POWER at the time that the initial break occurred, not in the boilers themselves, but in a large header to which they were connected, and upon which a gang of men were at work when the explosion occurred. Subsequent expert examination confirmed this conclusion.

READERS WITH SOMETHING TO SAY

Example of Poor Engineering

An example of what can happen when incompetent men lay out even a small plant is given in the following:

For heating four large greenhouses, there were three boilers, each 12 ft. by 52 in., fitted with ball-and-lever safety valves set to blow at 50 lb.

Unfortunately, the pipe work was done by a plumber whose knowledge of steam fitting was limited. As there was no provision for connecting the feed-water line to the boilers, he connected it to the bottom of the water columns. There was no blow-down pipe attached to the columns, but a pet-cock on the bottom gage-glass cock was used for this purpose. This manner of piping was suggested by the architect who built the greenhouses. On finding that the water level disappeared in the glass while feeding, they piped the line in through the blow-off connection.

Later the boilers and piping were put in service to test for leaks. The main run of piping was over 600 ft. long, and as no provision for expansion had been made, the end of the greenhouse was pushed out and nearly every joint caused to leak badly. No traps were installed to assist in caring for the returns. The return water was so hot that the pump slipped and slammed constantly while handling it.

As the stack at this plant was very short, the draft was furnished by two gas engine-driven fans. But with these fans the draft was so strong that the fire-doors soon warped so badly that they could not be closed tightly, thus admitting too much air over the fire.

The result of this installation was that the entire plant had to be remodeled at considerable expense, all of which could have been avoided by securing competent engineers to supervise the original installation.

J. M. Owen.

South Weymouth, Mass.

Care of Oil Piping

Most engines in modern power plants are provided with an oiling system which may give trouble from the overflowing of the oil onto the floor or into the flywheel and over the generator. The feed lines generally give less trouble than the returns, probably because the oil is usually under a head or pressure of several pounds This alone is enough to wash away small obstructions. Another reason is, that the oil has just been filtered and if the supply tank has a cover there is little chance for dirt to get into the line.

When certain grades of oil are used, it sometimes happens that sediment forms in the pockets of the feed lines, obstructing the flow. If possible the piping should be arranged to eliminate pockets, but in existing pipe lines a suitable blowoff can often be placed at the troublesome point to remove the sediment from time to time.

Fig. 1 shows a case that came under my observation where the horizontal line *A* became plugged with a thick substance which could be removed only by drawing a swab on a wire through the pipe. Placing a blowoff at *B* relieved the trouble.

When the engines are located in a mill or other exposed place, the oil will often congeal in cold weather and clog the pipes. A small steam coil in the supply tank will tend to relieve this trouble. Care should be taken

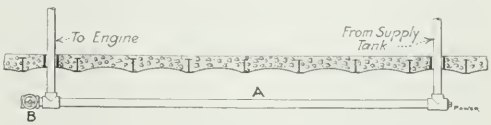


Fig. 1. Oil Piping through Floor

not to let the oil get too hot as it will lose its viscosity, and some of it may be evaporated and form an explosive vapor.

In some cases a small steam pipe is placed along both sides of the oil line as in Fig. 2. The steam piping, however, often gives as much trouble as the oil line itself. There is so much more piping to dismantle when making repairs, and the small leaks are a constant annoyance. In severe weather I have seen a ¼-in. steam pipe freeze at the low point of the line. As the pipes for the most part are hot, they interfere with wiping the engine.

Another point to remember is to avoid the use of rubber, as leaks are sure to develop. Sometimes these leaks are under the floor out of sight so that a large loss of

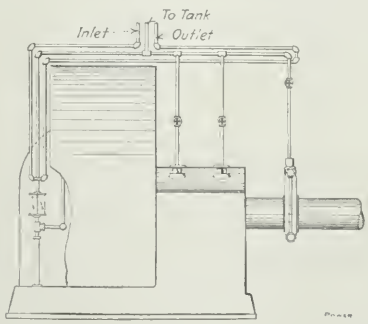


Fig. 2. Steam Piping to Keep Oil Warm

oil is possible before the leak is detected. There are several types of unions on the market having brass seats, and for flanges sheet lead makes an excellent joint.

The drain lines of an engine generally give the most trouble from stopping up and causing the oil basin or crankpit to overflow. Wherever possible long bends should be used. When the piping is to conform to the shape of the engine or foundations use a cross with two plugs instead of an ell or a tee with one plug. It will then be possible to blow out obstructions with an air hose, steam jet or even an ordinary hand bellows.

Oil piping should never be imbedded in cement floors. Where the piping passes through the floor, a piece of pipe of larger diameter should be inserted. The cement is then imbedded against the outer pipe and the oil line can be readily removed when necessary.

A great deal of trouble from plugged drains can be avoided by frequent cleaning of the pits under the crank and eccentric and back of the guides. Small pieces of packing will sometimes blow out and bits of waste fall in while wiping. A piece of screen over the end of the pipe will stop much of it from entering the pipes.

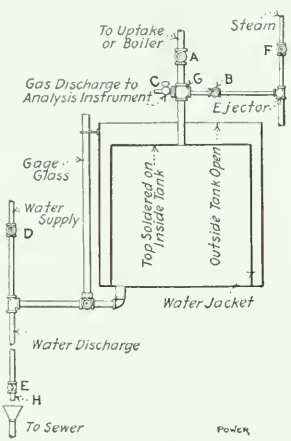
LEE GRANDMONTAGUE.

Youngstown, Ohio.

Flue-Gas Sampler

In our boiler room is a galvanized-iron, flue-gas sampler that is not expensive to make and collects a fairly average gas sample.

The outer tank is 2 in. larger in diameter and 1½ in. higher than the inner one. This allows 1 in. of water around and on top of the inner tank for a water jacket.



FLUE-GAS SAMPLER

One bottom answers for both tanks. If it is set on a wood shelf without any large cracks between the boards, the shelf will act as an insulator for the bottom.

Water is admitted and discharged through a connection at the bottom; gas is drawn in and discharged through a connection at the top. To fill with water, either valve *A*, *B* or *C* is opened and the valve *E* is closed, then the valve *D* is opened. Water will rise in the gage-glass as the tank fills. The top of the glass should be a little higher than the top of the inner tank, but not as high as the cross tee *G*. This will allow the water to overflow through the glass if *D* is left open too long without letting the oil film, which is maintained between the gas and water, to waste away through the valves *A*, *B* or *C*. This arrangement also prevents the operator from rupturing the tank by an excessive water pressure if the valve *D* were opened when the valves *A*, *B*, *C*, and cock *E* were closed.

To put the sampler in operation after the tank is filled with water, the valve *A* is opened and the pet-cock *C* closed, then the ejector is started by opening the valves *F* and *B*. By observing the water level in the gage-glass before and after opening the valve *B*, it is easy to determine the vacuum created by the ejector. After the ejector has discharged all the air, the valves *B* and *F* are closed and the valve *E* opened.

A short piece of pipe *H* is threaded on one end and plugged with soft metal. The plug has a small hole drilled through it, the diameter depending upon the rate at which the water is to be discharged from the tank. We have a set of these parts with various sizes of holes tested for various lengths of time, so that while operating the cock *E* is left wide open.

To draw out a sample for analysis the cock *E* and valve *A* are closed. The analysis instrument is connected to the cock *C* and when the valve *D* is opened enough to raise the water in the gage-glass a little, it puts a slight pressure on the gas and, by opening the cock *C*, the gas is forced to the instrument.

As there are no means for maintaining a constant discharge of gas, the discharge line should be made as long as possible. This makes a smaller proportional difference in pressure, due to the varying head of water in the tank.

The ejector was made by soldering the end of a seamless spout into the end of a ¼ and ⅜ by ¼-in. tee.

L. B. CASE.

Plainfield, N. J.

Available CO_2 Percentages

During the past year a number of articles have appeared in POWER relative to flue-gas analysis. The various writers mentioned results they obtained and the percentages of CO_2 they secured, but failed to mention how a certain percentage in a certain plant burning a certain grade of fuel is determined.

Nor did the articles I have read mention the relation of CO_2 to any particular grade of coal. There are a number of engineers who are commencing to use the Orsat apparatus or flue-gas recorders, and who are trying to obtain some of the percentages they have been reading about, without knowing that that percentage is not in the grade of fuel that they are using. They are trying to get something that is not there.

A quantity of pure carbon burned under laboratory conditions would only result in 21 per cent. CO_2, in other words, 21 per cent. is the theoretical maximum percentage of CO_2. The theoretical percentage of CO_2 in a given grade of coal, can be determined approximately, by multiplying the theoretical maximum (21) by the percentage of fixed carbon in the fuel. Thus, a grade of coal containing 70 per cent. fixed carbon has approximately

$$0.70 \times 21 = 14.7 \text{ per cent. } CO_2$$

The percentage of CO_2 that should result from the above sample of coal under everyday conditions, would then have to be determined by practical experience. I would say with tight boiler settings, properly designed furnaces and good judgment on the part of the fireman, 10 per cent. would be a good everyday average for the sample mentioned.

It must also be remembered that the percentage of CO_2 in itself, is not always an indication of efficiency. There may also be present CO or carbon monoxide. The pres-

ence of this gas in any quantity is absolutely detrimental to efficiency. Carbon when burned to CO_2 (laboratory conditions) will give 14,500 B.t.u. per lb. approximately. When burned to CO, the result will be only about 4400 B.t.u. per lb. As the object is to obtain the greatest possible number of heat units from a fuel, it will easily be understood why CO_2 alone is no positive indication of good management or efficiency.

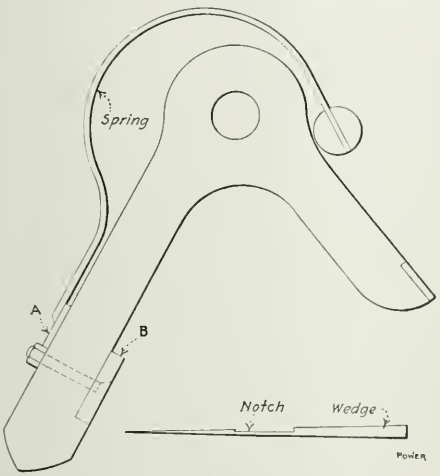
The sample should also be analyzed for CO.

Brooklyn, N. Y. A. POHLMAN.

Fixing Worn Latch Blocks

Frequently the steel latch blocks *B* on the grab-hooks of Corliss engines become worn enough to cause an intermittent valve action, which is very troublesome.

This trouble may be temporarily overcome by inserting a wooden wedge under the spring at *A*; the increased tension causes the steel latch block to engage deeper in the



WEDGE UNDER SPRING MAKES WORN GRAB-HOOK BLOCK ENGAGE

bell crank and the engine can be operated without interruption for a reasonable time, or until new blocks can be put in.

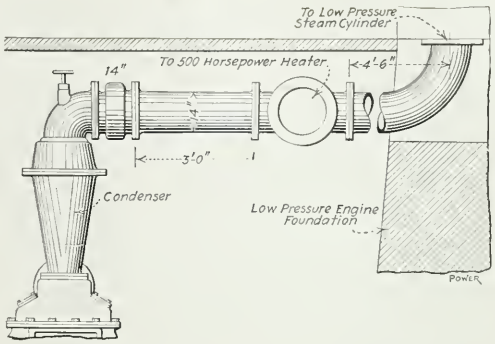
By notching the wedge, as shown, and driving it in until the spring sets in the notch, the wedge will remain under the spring indefinitely.

Louisville, Ky. J. F. HURST.

Exhaust Pipe and Vacuum Questions for Discussion

A discussion in POWER as to what constitutes a commercially tight exhaust-pipe line between the condenser and the low-pressure steam cylinder, we believe would be of interest. Also what should be the drop per minute in vacuum in this line, the engine not running, a vacuum of 26 in. existing in the pipe and the valve at the condenser closed?

We wish to secure the opinion of engineers who are considered authorities on the above subject, also to see how their opinions coincide with our own.



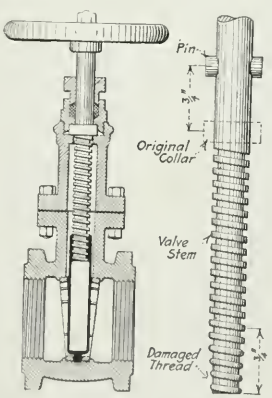
TYPICAL PIPING FROM ENGINE TO CONDENSER

The accompanying illustration shows a typical exhaust-pipe installation.

Fitchburg, Mass. W. L. BLAKE.
Blake Pump & Condenser Co.

Gate Valve Repair

In the following is described a repair to a 2½-in. gate valve used as a second valve on the blowoff pipe of a boiler, an angle valve being between it and the boiler. One day when attempting to blow down the boiler the valve would not open, although the handwheel turned freely. It was supposed that the stem was broken, but on removing the bonnet it was found that the threads at



HOW THE VALVE STEM WAS REPAIRED

the lower end of the stud had stripped until they were useless. The stem was removed, sawed off about three-quarters of an inch from the lower end, which removed all of the damaged threads; the collar on the upper part of the stem was also removed.

Then a ¾-in. hole was drilled above the collar and a pin driven through it. This pin served the purpose of the collar and allowed the stem to go further down in the valve body until the threads would engage with the valve disk, as shown in the illustration.

J. J. RAMSEY.

Wellington, Kan.

QUESTIONS BEFORE THE HOUSE

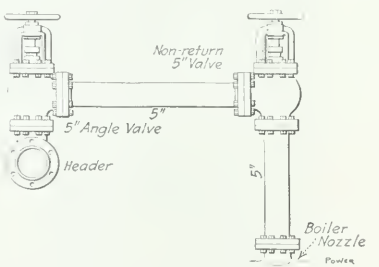
Safe Piping for Boiler Plants

The article by D. M. Meyers, under the above title, in the Dec. 10 issue, was read with interest. I believe the layout shown by him is all that he claims for it and also concur with him in his remarks on safety and efficiency.

In his illustration of the connection from the boiler to the header, there are two things with which I should deal somewhat differently. In submitting them, I wish to be understood as not criticizing Mr. Meyers, but as presenting another view.

I would use 5-in. piping and valves instead of 6 in. for the connections for the 78-in. by 20-ft. boilers. This gives a slightly more flexible construction and the first cost of material is less.

Also the 5-in. reverse-current or nonreturn stop valves will be found to give more satisfactory service on boilers of this size than the 6-in., because, being of less area through the port, the disk will rise higher from its seat



Arrangement of Lead from Boiler to Header

and, combined with the more constant rate of flow of steam, there will be less tendency for the valve disk to float up and down at each stroke of the engine.

Using a valve larger than required has, to my knowledge, been the cause of several nonreturn valves of reliable make being condemned. The continual movement induced by the pulsating flow soon wears the dashpot and allows the valve to beat itself to pieces.

I have used 5-in. connections on 84-in. boilers and when working them to overload limits have failed to discover a measurable loss of pressure between the boiler and the header. For valves like that, and piping between the boiler and the header, as shown in Mr. Meyers' illustration, I prefer using two angle valves rather than globe valves, or a gate and a globe valve. Some makes of these are identical in dimensions, differing only in internal construction, adding symmetry to the job.

The advantages of this arrangement are that there are two less flanged joints, the valves taking the place of the elbows; there is a longer, hence more flexible, piece of pipe for the horizontal member, and there will be less friction with the steam passing through two angle valves than through two globe valves. Also the draining of the piping is better done at times of banked fires or dead boilers, with the nonautomatic valve left open, which is usually the practice when the automatic valve is tight, as there is a chance for water to accumulate between two globe valves on a horizontal line. A drip between the valves is a wise precaution, however, and should always be a part of the piping.

Charles L. Ware.

Maynard, Mass.

Efficiency and Repair Costs of Fuel Economizers

Referring to the interesting article, "When to Install a Fuel Economizer," by Everard Brown, in the Dec. 31 issue, I would offer the following comment without intending any special antagonism. Having installed many separate economizer equipments in this country during a period of 20 years, I believe I am competent to speak from the practical standpoint of experience.

Nearly every writer credits the economizer with only the theoretical efficiency, due to the heat units recovered and put into the feed water by its use, while it is seldom that the economizer saving under ordinary operating conditions does not reach a much higher percentage. George H. Barrus, after testing many plants with and without the economizer service, stated to me that he came to the conclusion that results showed that approximately 8 deg. rise in feed-water temperature equalled 1 per cent. of fuel saving. Another expert, F. W. Dean, obtained 11 per cent. saving with 125 deg. rise at another plant and many similar results by the ablest experts in the country have invariably shown the same proportion. The answer to why this is true may be readily accounted for by any of the various following reasons:

Perhaps the draft is automatically diminished for the smaller amount of fuel required with the economizer, making a consequent less excess of air and better furnace combustion. Or the reduced work on the boilers leaves them, however, with the same heating surface to perform less duty and hence they are more efficient. The purer water obtained by the use of the economizer is more efficiently evaporated. The frequent need of another boiler to supply merely an extra half or quarter boiler output, is obviated with the economizer service.

In regard to the charges against the economizer, it is not necessary to theorize, as there are 60 and more years of experience, which is enough to know accurately what these charges are.

Repairs—I recently went through my repair book, taking everything for the year, and found less than 0.2 of 1 per cent. on over two million dollars' worth of installations. Many of the machines were 20 to 30 years old. As this account included labor costs, there could be very little aside from this that the owners could have done themselves.

Attendance—Attendance is only required for blowing off daily and removing the soot once a week, which takes about two to three hours. As I have never known a case of any increase in the regular payroll for economizer work, 1 per cent. to this item would seem more than ample. Even this would seem to be offset entirely if there is less boiler cleaning and much less coal and ashes handled as is usually the case.

From the above it would seem justifiable to call repairs and attendance 2 per cent., interest 5 per cent., and depreciation 5 per cent., or 12 per cent. to cover all annual charges against the economizer cost. Economizers have been installed which have been in service night and day and have never had any attention until something happened and thus on the whole incurred more expense than others, but these were included in the whole repair account which figured as I stated, so such exceptions would clearly prove the rule to be right.

H. G. Brinckerhoff.

Boston, Mass.

Isolated Plant vs. Central Station

When the engineer becomes more familiar with the question, I cannot see why it cannot be settled definitely in favor of either the central station or the isolated plant, without argument. Although these arguments bring out facts that are of value, Mr. Lewis' statement in the Jan. 7 issue shows lack of equity. It is evident that in the building to which he refers the load conditions are peculiar, but no more so than are evident in all office-building plants, although greatly modified.

As Mr. Lewis is evidently promoting central-station interests he has to consider that the conditions mentioned also exist in the central-station load factor. If the building referred to were in Boston, something would be wrong, unless the central station gives rebates for basement room or for other privileges.

If the Boston Edison Co. were installing a 150-kw. service in the building referred to it would cost $132.50 per month, or $5190 per year, for a fixed charge, whether current were used or not, making the fixed charge $2790 more per year than the $2400 as charged against the isolated plant by Mr. Lewis, which is erroneous, because he states $20,000 represented the approximate sum total of all the material and labor which would enter into the installation of the plant. This being so, he charges 5 per cent. for depreciation and 2 per cent. for repairs on money spent for labor for which only interest should be allowed.

Then the cost of electricity, according to schedule "D" of the Boston Edison Co., which would be five cents on the first 1500 kw.-hr. and three cents for the remaining 2666 kw.-hr., would aggregate $154.98. A fixed charge of $132.50, as before stated, would give a total of $587.48 per month. This divided by the kilowatt-hours consumed would give a cost of 14c.+ per kw.-hr. This amount of electrical energy would be obtained for 10c. per kw.-hr. on a straight lighting rate. Some difference between the actual cost and Mr. Lewis' 1.8c. per kw.-hr.

More labor would be unnecessary and the extra coal used during the summer months would not be very much, because the days are long and but little light would be used. During the winter, when the peak load is noticeable, the exhaust can be partly used for heating purposes.

Various other erroneous assumptions are noticed, but what is the use of saying more.

M. W. Eastman.

Cambridge, Mass.

Some interesting statements are made by Mr Lewis. For instance, he says they operate their own hydraulic steam pump, and heat the building with direct radiation. It must be taken for granted that a boiler plant is already installed, therefore, a certain amount of coal must be consumed to operate the appliances mentioned. Hence this expense cannot be charged to the electrical plant. Furthermore, Mr. Lewis says the approximate cost would be $20,000 for one 25-kw. and two 100-kw. machines. I do not know on what he bases his figures, but I am free to say that amount can be divided by two with safety and still have a margin left.

Now getting down to some kind of a basis. Say the plant requires ten tons of coal per day to operate the machinery in the building prior to the time this estimate was made, and they then install three generating machines, and produce the electrical energy used in the building, how much more coal would be consumed and how much more help would be required? According to his own figures, 50,000 kw.-hr. was purchased per year, or about 137 kw.-hr. per day, 365 days per year. With an uptodate outfit, a kilowatt-hour can be produced with 8 lb. of coal.

$$8 \times 137 = 1096 \text{ lb.}$$

Call it 1200 lb. at $2.50 per ton; then it would be $1.50 per day. Take the cost of the new installation at $10,000 and allow 5 per cent. depreciation; this with 6 per cent. interest on the capital invested would make a final charge of $1100 for the first year. Depreciation must be credited back to the original investment and it will be less each year, consequently the first charge of $1100 must be less every year. Depreciation and interest would be about $3 per day; this added to coal cost is $4.50.

Now to be fair to the electrical end of the plant we must credit back to it the total expense of operation prior to the installation of this part of the plant which with the data given cannot be done, but it is safe to say we would get our current for almost nothing.

The following are accurate data pertaining to one isolated plant. It consists of three direct-connected units; one 35-kw., and two 125-kw., three-wire machines. The original cost was $17,000.

For the month of last November there was produced 36,635 kw.-hr. This generated at 0.025c. per kw.-hr. (central-station rate here) would be $915.875. There was 934,373 lb. of condensation from the heating system which at the central-station rate of 35c. per 1000 lb. would cost $327.03. This added to the charge for current would be $1242.90. The cost of operation was $728.56, not including taxes, which are taken care of in the interest charged. This deducted from the earnings, if the current and steam were sold at prevailing rates, leaves $514.34 profit for the plant. The foregoing figures are accurate, as all current is metered, coal and ashes weighed, water metered and the condensation is metered. All meters are read every six hours.

If this showing can be made in one plant there is no reason why it should not be done in others. The main thing for the engineers to do is to establish a form of

accurate records, get yearly data and have it ready for the central-station man when he comes.

P. J. Hickman.

Erie, Penn.

Mr. Lewis' facts are so few that it is difficult to make an intelligent analysis of his case. He does not state in what section of the country his building is located, but ordinarily the lighting load creeps up very rapidly in the winter months, beginning a little before four o'clock.

Evidently the building has the advantage of unobstructed light on four sides, and no inside offices, as the claim is made that the lights are used only for halls and elevator shafts until five o'clock in the evening.

He does not state whether, from lack of forethought or otherwise, the owners or designers of this building installed low-pressure boilers for heating purposes, as unfortunately is often the case, notwithstanding the fact that the cost of high-pressure boilers is only a trifle greater. Even estimating it was necessary to install new boilers to operate the proposed plant, he evidently has some very extraordinary conditions to overcome, to require an expenditure of $20,000.

It is reasonable to assume that two 75-kw. and one 25-kw. units would be ample to meet his requirements, particularly, as he states the maximum load would be of such short duration. The ordinary installation of a generator plant in a new building that would amply meet conditions, such as stated, should cost less than $10,000, which, even with such a very low power factor, would bring the fixed charges down to 2.4c. per kw.-hr.

Harry J. Marks.

New York City.

Self Instruction in Engineering Mathematics

In your editorial in the Feb. 18 issue on the above subject, the statement is made that it is only of late that books have been available from which a man of ordinary intelligence could learn the essentials of higher mathematics, particularly as it relates to engineering. A man who is past middle age and whose education has been neglected has quite an ordeal before him should he attempt to get an insight of the higher mathematics from most of the textbooks published on that subject nowadays. I have a good library of mathematical works, some of which were printed one hundred years ago. Also many which were published in 1911 and 1912 and from a comparison of the earlier with the later ones, I would state that the man who is striving to educate himself would learn more with less effort from those works published sixty years ago.

The names of modern writers on mathematics are legion, and 99 per cent. of their works is entirely worthless to the man who must instruct himself.

The writer, himself a burner of the midnight oil, would recommend the following works to those who are trying to better their condition: Eaton's "High School Arithmetic"; Loomis' "Algebra"; Ray's "Higher Algebra"; Bonnycastle's "Mensuration"; Loomis' "Trigonometry"; Blanchet's "Legendre"; Loomis' "Elements of Analytical Geometry"; Ball's "Applied Mechanics"; Olmsted's "Philosophy"; Olney's "General Geometry and Calculus."

The above with the valuable aid of Power will advance any student far beyond his fondest expectations.

James McClure.

Fletcher, N. C.

Four-pass Boilers

I have been very much interested in the discussions in Power in regard to the number of passes in horizontal water-tube boilers. It seems to me that in a discussion of this kind we should assume a broader scope to draw any value from our conclusions.

In the Feb. 25 issue of Power one writer takes as an example a boiler operating at normal load and shows that with the gas temperatures obtained with a boiler so operated there is no saving by adding an extra pass.

The tendency now seems to be to force the boilers, i.e., run considerably over rating. Some of the best known stoker builders make a point of the overload capacity of their stokers. With boilers using forced draft and operated at from 150 to 250 per cent. of rating, the gas temperatures in the first pass would be from 1000 to 1200 deg. instead of 800 deg. as figured at rating, which would result in increasing stack temperatures above 500 deg.

In a case of this kind it would seem that the four-pass idea could be used possibly by decreasing the pass areas and giving the gases a longer travel over the cool tubes before reaching the stack. This would decrease the stack temperatures as well as increase the efficiency of the boiler by the greater heat transfer between the gases and steam due to the increased velocity of the gases. At just what point the gain to be realized will be offset by increased trouble, due to leaky baffles, would have to be determined by experience, but my opinion is that boiler companies will guarantee tight baffles at a considerably greater pressure of gases than is common in most boilers.

When it is known boilers are to be run over rating, a point which should not be overlooked in design is ample clearance space between the fire and lower row of tubes, as otherwise the gases, with their increased velocity, will reach the cold boiler tubes and become chilled before complete combustion takes place and the result will be an excess of black smoke coming from the chimney. I believe ample space between the tubes and fires is a much more effective way to obtain complete combustion than a scheme of horizontal baffling along the lower tubes, such as is shown in the Mar. 11 issue, page 328. The objection to the way of baffling is that besides causing pockets for dead gases over the lower baffle and under the upper baffle, it causes the gases to flow parallel to the tubes and is not as efficient as if the gases impinged on the tubes at right angles to them.

Such baffling, besides being very severe on the tile, as the writer points out, throws the gases toward the front header and subjects that to very severe conditions. If the boiler is so placed that sufficient space is not available for good combustion under the tubes it would be better to extend the front of the setting rather than try and get the Dutch-oven effect under the first pass. I do not wish to be understood as advocating a high overload on boilers, especially when economy of operation is a factor, but knowing that boilers are so operated, I am merely offering a suggestion as to how to increase their efficiency.

L. P. St. Cyr.

Dansville, N. Y.

INQUIRIES OF GENERAL INTEREST

Calking Butt Strap—If a butt strap on a boiler is leaking should it be calked on the outside or inside?

R. W. B.

All calking should be on the outside, because it will not spring the shell so much as the inside strap is much wider.

Lowering Receiver Pressure—How can the pressure in the receiver of a compound engine be lowered without lifting the relief valve?

E. M. W.

By lengthening the low-pressure cutoff, causing the low-pressure cylinder to take more steam.

Pump Delivery Against Different Pressures—Will a pump discharge the same quantity of water against a pressure of 100 lb. as it will against 10 lb. if the piston speed remains unchangd?

C. S.

The amount of water delivered is independent of the discharge pressure if the piston speed and slip are the same.

Engine Efficiency—What is the efficiency of an engine when its indicated horsepower is 563.74 and its brake horsepower 484.25?

E. S.

The mechanical efficiency of the engine is

$$\frac{484.25}{563.74} = 0.859 = 85.9 \text{ per cent.}$$

Absolute Condenser Pressure—When a vacuum gage on a condenser shows 27 in., what is the absolute pressure within the condenser?

S. E.

Assuming that the atmospheric pressure is 14.7 lb. per sq.in., the absolute pressure corresponding to a vacuum of 27 in. is

$$14.7 - (27 \times 0.49) = 1.47 \text{ lb.}$$

0.49 is the pressure corresponding to 1 in. of mercury.

Water Head for Atmospheric Pressure—What is the height of a column of water that would be supported by atmospheric pressure?

D. M.

It is usually given as 34 ft. Figured on the basis of 2.309 ft. being the height of a column of water corresponding to a pressure of 1 lb. per sq.in., the actual height of a column that would correspond to an atmospheric pressure of 14.7 lb. would be

$$2.309 \times 14.7 = 33.9423 \text{ ft.}$$

Too Short Cutoff—In a certain plant a 10-hp. motor was doing the work which a 35-hp. engine would not do. The trouble was that steam lap had been added so freely, and the eccentric advanced so much that the port opening was, for a very short period of time, cutting down the range of cutoff to a small fraction. How could the trouble be remedied?

J. N. A.

There are three remedies cutting off the steam lap and putting back the eccentric; getting an eccentric with greater throw, or putting on a rocker arm which will increase the valve travel giving a wider port opening.

Pump Delivery—What will be the discharge in gallons per minute of a pump having a 4-in. water cylinder and operating at an average piston speed of 60 ft. per min.?

M. D.

If the slip is neglected the delivery will equal the displacement of the piston or

$$\frac{4 \times 4 \times 0.7854 \times 60}{144} = 5.236 \text{ cu.ft.,}$$

which equals

$$5.236 \times 7.48 = 39.165 \text{ gal. per min.}$$

Pump Discharge Calculation—How much water will be delivered by a 14x8x12-in. pump making 1086 ten-inch strokes per hour?

M. N. S.

The water cylinder being 8 in. in diameter, its cross-sectional area would be

$$8 \times 8 \times 0.7854 = 50.265 \text{ sq.in}$$

Neglecting the space occupied by the piston rod making a 10-in. stroke, the displacement per stroke would be

$$50.265 \times 10 = 502.65 \text{ cu.in.}$$

and neglecting slippage the discharge would be

$$\frac{502.65 \times 1086}{231} = 2363.1 \text{ gal. per hr.}$$

Injector Acting Against Different Pressures—Will an injector put water into two boilers that are under different steam pressures, as 90 and 120 lb. respectively, if the injector is supplied with steam from the boiler under the lower pressure?

E. S. C.

Injectors are made which, when supplied with exhaust steam of as low as 2, 3 or 4 lb. pressure, will feed boilers. Injectors may be made to feed boilers carrying 120 lb. pressure when the injector is supplied with steam at only 90 lb. pressure. Ordinarily injectors are constructed to operate when supplied with steam of the same pressure as that carried in the boiler which the injectors feed. The action of an injector is not dependent upon pressure except as that is translated into velocity, as explained in the answer to the inquiry "Exhaust-Steam Injector," on page 353 of the Mar. 11, 1913, issue.

Selecting a Dynamo—What kind and size dynamo would be suitable for lighting 250 sixteen-candlepower lamps and driving a 10-hp. motor, 800 ft. distant?

A. O. K.

A 25-kw. compound-wound, 220-volt, direct-current generator would seem most suitable. Instead of 110 volts, 220 is recommended on account of the distance to the motor, as the higher the voltage the less the transmission loss for a given amount of energy. A capacity of 25 kw. should be ample for the load contemplated.

A 16-cp. carbon-filament lamp takes 55 watts, hence

$$250 \times 55 = 13{,}750 \text{ watts}$$

is the lighting load.

A horsepower equals 746 watts, hence

$$10 \times 746 = 7460 \text{ watts}$$

is the motor load, and the combined load

$$13{,}750 + 7460 = 21{,}210 \text{ watts or } 21.21 \text{ kw.}$$

A compound-wound machine is advised as giving better regulation than one shunt-wound.

Compressor Trouble—A wet gas compressor, used for cooling two ice boxes, gives the required temperature, 32 deg. F., but at intervals runs so cold that the packing leaks and the oil seems to freeze. Then suddenly the discharge pipe will warm up and the piston rod become hot. These sudden changes will continue all day. Closing down the expansion valve to get warmer gas to the compressor causes the suction gage to go down to 10 lb. Under present weather conditions (Mar. 25) the high-pressure gage will be as low as 90 lb. What is the trouble?

J. W. W.

Apparently the machine is operating at too great speed to do the required work at this time of the year. If the compressor is slowed down and the back pressure thereby increased to the proper amount, say 15 to 20 lb., the operation will be more regular.

Lately it has been found that these machines should be operated with a hot discharge, from about 180 to 250 deg. F., with a condenser pressure ranging from 90 to 185 lb.

Alternate freezing and thawing off of the suction pipe or hot or cold discharge may be due also to an insufficient amount of ammonia in the system.

A condenser pressure of 90 lb., if the liquid piping is properly proportioned, is an advantage as it saves power and consequently reduces the cost of operation. Some information on this subject is given on page 420, Mar. 25 issue, "Winter Work in Refrigerating Plant."

ENGINEERS' STUDY COURSE

Answers to Review Test Questions

(1) The number above the line (1680) is the numerator and that below the line (144) is the denominator.

(2) $\frac{22,043}{32} = 688\frac{27}{32}$.

(3) 34,840.

(4) No.

(5) $44\frac{5}{32} + 51\frac{18}{64} + 202 + 751\frac{1}{4} = 326\frac{13}{32}$.

(6) $242\frac{4}{16} - 229\frac{7}{16} = 12\frac{13}{16}$.

(7) $19 - 18\frac{5}{32} = \frac{27}{32}$.

(8) $193\frac{1}{4} \times 225\frac{7}{8} = \frac{79}{4} \times \frac{181}{8} = \frac{14299}{32} = 446\frac{27}{32}$.

(9) Dividing the numerator or multiplying the denominator divides the fraction.

(10) 9 in. equals 0.75 of a foot.

(11) 1 gal. = 3.785 liters.

(12) 1 mm. = 0.03937 in. or $\frac{1}{25}$ in. nearly.

(13) 13,500 B.t.u. × 0.252 = 3402 large calories.

(14) No; the volume of a barrel has never been definitely standardized.

(15) 212 deg. F. = 100 deg. C.

(16) The actual price is $16.20.

(17) 1760 lb. combustible.

(18) The ratio of heating to grate surface is 15.08 to 1.

(19) The inverse ratio of 20:4 is 4:20 = $\frac{1}{5}$.

(20) 400:220 = 3:1.65 hr. Delivering 400 gal. per min. the pump will fill the tank in 1.65 hr.

(21) $2213\frac{1}{4}^2 = 50,512.5625$.

(22) $\sqrt{789} = 28.089$.

(23) From the formula the diameter should be 3.178 in.; the commercial size shaft to use is $3\frac{7}{16}$ in.

(24a) $33 \times 3 = 99 = \log 1.995635$.

(b) The log of 31,428 = 1.4973167.

(c) log 4.4980071 = 31,478.

(d) 31,444.73 = log 4.4975479.

(e) log 4.4931343 = 31,126.8.

(f) $642^3 = 286.15$.

(26) There are 270 deg. in $\frac{3}{4}$ of a circle.

(27) Side = $\sqrt{\frac{21.217}{0.433}} = 7$ in.

(28) The plane is 1882.43+ ft. long.

(29) 26.928 gal. will be needed.

(31) $V = \frac{1}{3} h\ (B + b + \sqrt{B \times b})$.

(30) Average circumference.

In the first line of example (32) of the Apr. 8 issue a typographical error appeared. The value of a long ton was given as 2140 lb. instead of 2240 lb.

(32) The coal pile will weigh approximately 1356.032 tons.

(33) $11^3 \times 0.5236 \times 0.26 = 181.197$ lb.

Lessons to Come

Most steam plants do their work by virtue of the heat contained in coal. The combustion of coal is, therefore, an important subject and one which every engineer and fireman should understand. This subject will be made clear and, we believe, interesting in the series of lessons to begin in the next issue.

Instructions will be given for making much of the apparatus used for getting samples of coal and for making coal and flue-gas analyses.

These lessons will be of value to firemen as they explain how to save coal. This, firemen are glad to do if they know how. The more they save the less they have to shovel and the less are the coal bills.

If there are any points that were not clear in the Mathematics Course we will be glad to have our readers write us of their difficulties and we will answer them by letter, and where the questions warrant it, will print them and their answers in the department "Inquiries of General Interest."

Federal Help for Oregon Power Projects

A contract between the United States Government and the State of Oregon was approved by the Secretary of the Interior, Franklin K. Lane, on Mar. 27, whereby the secretary agrees to withdraw sufficient land and the Oregon state engineer hold the necessary water for the projects under investigation. A project may be released to private interests providing they pay the cost of preparing plans, if the development is in harmony with the public plans for the best uses of the Oregon waters.

There is now available $100,000, one-half of which each party is to pay. This sum will be spent mainly on the investigation of the Deschutes River project, embracing 300,000 acres. The start will be made on the Tumalo Creek unit of 35,000 acres, for which Oregon has made a construction appropriation of $450,000. Secretary Lane will allow an equal amount for the entire project.

When completed the Deschutes undertaking will have cost about $8,000,000. If Oregon will raise $4,000,000 toward the construction of this project, Secretary Lane believes that an equal amount could be drawn from the reclamation appropriation for this work.

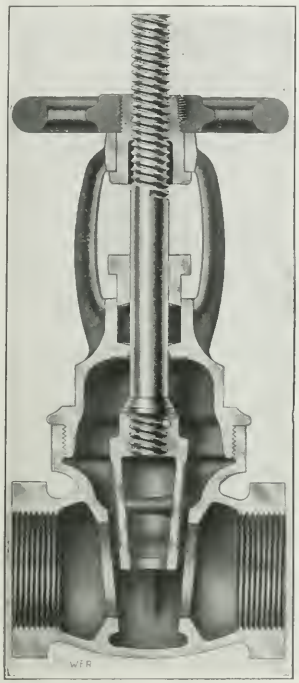
Jenkins Brass Gate Valve

In the valve, illustrated herewith, a yoke and traveling spindle are used. As the spindle threads are exposed they are easily lubricated, materially increasing their durability, particularly when the valve is used in dry- or superheated-steam lines. The traveling spindle is raised or lowered through the handwheel as the valve is opened or closed.

The valve has a solid, double-faced metal wedge or gate, guided by ribs cast on the inside of the body, which fit in corresponding channels in the wedge, thereby preventing the wedge from dragging across the seat. The rib on one side of the body is of a different thickness from that on the opposite side, and as each channel in the wedge fits its corresponding rib, it is impossible to reverse

the wedge in the valve. All parts are interchangeable.

The body is globe shaped, a design which gives a neat appearance, and full opening. The valves are made in three distinct patterns: standard, for 125 lb. steam pressure, or 175 lb. water pressure; medium, for 175 lb. steam, or 250 lb. water, and extra heavy, for 250 lb.



New Jenkins Brass Gate Valve

steam, or 400 lb. water. This valve is made screwed or flanged in either straightway or angle type, with unions for radiator work, and with hose ends, the hose valves conforming with the underwriters' specifications. It is made in all sizes from $\frac{3}{4}$ to 3 in. inclusive, by Jenkins Bros., 80 White St., New York City.

⁂

The Bureau of Mines announces the following new publications: Bulletin 63, "Sampling Coal Deliveries, and Types of Government Specifications for the Purchase of Coal," by G. S. Pope; it describes in detail methods of sampling and reasons therefore and cites new specifications for purchase of coal by the Government. Technical Paper 31, "Apparatus for the Exact Analysis of Flue Gas," by G. A. Burrell and F. M. Seibert. The Bureau of Mines has copies of these publications for free distribution. Order them by number and title, addressing the Director of the Bureau of Mines, Washington, D. C.

We have just received the bound volume of the 1912 "Proceedings" of the American Electric Railway Engineering Association. It is got up in the same attractive form as former volumes and, besides the matter pertaining purely to electric-railway affairs, it contains the report of the committee on power generation. This report gives in detail the practice of several large electric companies, as regards the purchase, specifications and testing of coal and lubricating oils, also the analysis and treatment of boiler-feed waters.

The "Proceedings" are published from the office of the secretary of the association at 29 West Thirty-ninth St., New York.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"The reassuring notes of factory whistles will relieve the distraught minds of those who are still nerve-racked and ill." This is an optimistic note from Dayton, Ohio, that should ring louder and louder. There is not much room for sorrows while we are working, and it's just as well to forget them when we can.

⁂

What do you know about this? The Steel Corporation has refused to operate its mills on Sundays. There's no use in having a reputation as a wicked trust, and then refusing to live up to it. Of course, a power-plant engineer can, and usually has to, work on Sunday, but who are we, anyhow?

⁂

Ever since you and I were knee-high to grasshoppers, we've had dinged in our ears: "Get out of the rut! Don't dig a rut for yourself!" Now, along comes a writer on industrial economics who says: "The real secret of success is in establishing ruts of a useful kind; ruts with switches that may be operated by the mind at will." Soon we'll have to pay ten dollars a pair for second-hand, well-worn ruts that once could not be auctioned off at a rummage sale at five cents a bunch. Where do we get off, anyhow?

⁂

The Standard Oil Co. has agreed to pay wages for life to Vincent Pelican, Constable Hook, N. J., "who was injured in the company's employ," wherever that is. The intention is good, and as this growing little concern appears to be getting along right smart, we hope it will manage to scrape up enough to carry out this laudable undertaking.

⁂

If you were asked to give your definition of a gentleman, we bet one of those new nickels that looks like a button on little Lizzie's winter coat that you can't do better than this:

"A man that's clean inside and out; who neither looks up to the rich nor down to the poor; who can lose without squealing and who can win without bragging; who is considerate of women, children and old people; who is too brave to lie, too generous to cheat, and who takes his share of the world and lets other people have theirs."

And this standard works out as well for the overalls as for the joyous habiliments of swell society.

⁂

A TALE OF A TAIL

By Billy Spills

This is a tale of a horse's tail electrically waved from Australia, but not exactly verbatim.

'Twas a dark and stormy night on the plains, and Antonio was madly galloping on his fiery steed, or rather, the horse was galloping and Toni was doing the mad end of it. A blinding flash, and directly in the path of the travelers a giant oak was struck by lightning blim! blam! just like those. The dispatch says "the tree was split in halves"—you know, two halfs. And right here hangs the tale of a tail which, shortly, will hang no longer.

Was Bucephalus (Australian for "horse") intimidated by the two halves of this acorn hatchery that yawned and gaped before him—before even him and Toni could yawn or gape? Nein! Non! Nem! Nej! Niet and just plain No! [The "no" in six languages is to display the author's education.—Ed.]

What did 'Cephy did? He showed his rearing by rearing, and then bounded through the gaping gap, right between the two halves—all but his tail. To the west he madly made, but eastwardly there was trouble in the Balkans, in a manner of speaking. Them two halves suddenly became as one whole one—and shut up! The tail was clutched in the oak's crool embrace even as clutches the octopus with his ten tackles (number uncertain.) The tail was severed at the roots—the tail's roots, not the tree's roots, you understand.

This is the end of the tail tale, really. For aught we know, the horse is running yet—like one of those sure things in the second race—but "the tail can still be seen protruding from the tree." By this time the sturdy oak may have been lutherburbanked into a horse-chestnut tree.

Toni? That we should worry! But as it was the end of the tail that began this tale, at the tail end it is only fair to add that "the young man received a severe shaking, but otherwise came through the ordeal safely."

Steam Consumption of 4-Valve Engines

SYNOPSIS—For engines of different makes, differences in the water rate of 10 lb. per i.hp.-hr. are readily possible, and even for the same make of engine the rate may vary several pounds.

Engines of similar type, built by different manufacturers, are sometimes erroneously assumed to have about the same steam-consumption requirements. This impression is probably gained from the fact that similar types of other machines of various builders, for instance, electric generators, have about the same efficiencies. To show that there is a considerable difference in steam consumption between engines of the same type but of different make, and even engines of the same make, the Harrisburg Foundry & Machine Works recently submitted the data presented herewith. The accompanying table gives the results of a series of tests conducted by a number of prominent mechanical engineers on nonreleasing fourth load and 25 per cent. overload. In the smaller engine the difference is 2.95. Between the limits given, the economy would, therefore, be very nearly uniform under varying load conditions, and at the higher pressures of previous tests would surpass earlier attainments.

To illustrate the variation in steam consumption between engines of different make, a number of guarantees from Government bids are submitted. It will be recognized that in Government negotiations the fulfillment of guarantees is a vital part of the contract and failure to meet them results either in the rejection of the machine or an acceptance with a heavy penalty imposed. This, of course, would tend to make the guarantees of steam consumption conservative, but as bids are usually compared on an evaluation of steam-consumption guarantees, an incentive is offered the bidder to cut down his guarantee to the lowest limit and still come within the possibilities of his engine. Under these circumstances, a comparison

TEST DATA ON FOUR-VALVE ENGINES

Test No.	Date	Mech. Engineer	Cyl. Dia., in.	Stroke, in.	Speed R.p.m.	Ft. per Min.	Initial Pressure, Lb. Abs.	Quality	Steam Rate, Lb. per I.Hp.-hr. ¼ Load	½ Load	¾ Load	Full Load	1¼ Load	Minimum B.t.u. per 1 Hp.-hr.	Maximum Efficiency Rankine	Thermal
1	4-16-1905	H. W. Spangler R. G. Carpenter	16	16	210	560	140	Dry Sat.	30.37	23.89	22.24	22.74	23.61	3637	70	11.30
2	6-28-1905	H. Diederichs	19	19	205	649	135	Dry Sat.	.....	23.9	22.46	22.27	.....	3584	71	11 29
3	9-20-1911	C. F. Sponsler	15½	16	210	560	140	Dry Sat	26.9	22 2	21.7	22.0	23.0	3549	71 7	11 58
4	10-18-1911	H. M. Price	14	15	250	625	125	Dry Sat.	26.55	21.5	21 15	21.06	21.62	3274	77 7	11 96
5	8- 0-1912	M. C. Hartman	14½	16	225	600	155	Dry Sat.	26.34	20.8	19 8	20.46	21 6	3384	75.2	12 67
6	12- 0-1912	H. M. Price	17	18	220	660	125	Dry Sat.	24 7	21 25	20.9	21.17	22.9	3249	78.3	12.05
7	12- 0-1912	H. M. Price	14	16	250	666	125	Dry Sat.	25.18	21.5	21.25	21.27	22.23	3303	77	11.85

Corliss valve-gear engines made by this company. The exhaust was into the atmosphere in each case.

Test No. 1 in the table, conducted by the late Prof. H. W. Spangler, of the University of Pennsylvania, established a record at the time. This test was soon followed by another conducted by Profs. R. C. Carpenter and H. Diederichs, of Cornell University. The results agree closely with the former test and tend to substantiate its accuracy.

In test No. 3, conducted by C. F. Sponsler, chief engineer of the Bureau of Standards of the United States Government, the operating conditions were the same. It may be noticed that the results were bettered at each point of the load and that the curve of steam consumption was flattened to a considerable extent; that is, the steam consumption at one-fourth load more nearly approaches that of full load. This would give a high average efficiency under varying conditions of load.

In test No. 4, H. M. Price, mechanical engineer of the Treasury Department of the Government, secured some still lower results, partly due to the higher speed. These results were bettered on a slightly larger engine by M. C. Hartman, consulting engineer for the Webster Safe & Deposit Co. of Chicago. A steam consumption of 19.8 lb. per i.hp.-hr. was obtained. This is slightly lower than the full load rate of 20.46. In this test, the steam pressure was 155 lb. abs. as compared with 125 lb. abs. in test No. 4.

In tests Nos. 6 and 7, both conducted by H. M. Price, the minimum steam consumption is not as low as obtained in test No. 5. The curves of steam consumption for different loads, however, are flatter. In the larger engine there is a difference of only 1.8 lb. in the steam consumption per indicated horsepower-hour between one-

of guarantees submitted will tend to show the capabilities of the engines.

Among bids offered the Bureau of Standards were two proposals on a nonreleasing Corliss valve engine of 190 hp. capacity with an initial pressure of 140 lb. abs. and atmospheric exhaust. The guarantees are appended as Bidder A and Bidder B, the quantities being pounds of dry steam per indicated horsepower-hour.

Loads	¼	½	¾	Full	1¼
Bidder A	33.2	26.1	25.0	25.6	27 6
Bidder B	32.0	24.0	22.5	23.0	23.8

On Mar. 15, 1912, bids were received by the Treasury Department on a 160-hp. engine to operate between 125 lb. abs. and atmosphere, having guarantees as follows in pounds of dry steam per indicated horsepower-hour:

Loads	¼	½	¾	Full	1¼
Bidder A	31.0	25.0	23.2	23.5	24.0
Bidder B	...	30.5	25.5	23.5	25.5
Bidder C	27.5	22.5	21.4	21.75	22.5

On May 6, proposals for a 100-kw. engine to the Treasury Department brought out the following guarantees, the quantities being in pounds of dry steam per kilowatt-hour. An initial pressure of 125 lb. abs. and atmospheric exhaust were stipulated. All bidders offered the same generator, so that the data really compare the engines:

Loads	¼	½	¾	Full	1¼
Bidder A	75.6	47 8	42 9	41.9	43 4
Bidder B	60.6	41.9	37.9	37 1	38 3
Bidder C	56.8	37.8	34.0	33.7	34 7

On Nov. 25, 1912, the Treasury Department opened bids for 100- and 200-kw. units to operate on an initial pressure of 165 lb. abs. and against atmospheric pressure. The following guarantees were offered for the larger machines, the quantities being given as before in pounds of dry steam per kilowatt-hour:

Loads	¼	½	¾	Full	1¼
Bidder A	56.2	40.4	37.0	37.45	39.4
Bidder B	54.0	39.0	33.5	33.5	35.1
Bidder C	68.2	42.8	37.6	37.8	40.8
Bidder D	52.3	38.0	34.1	33.3	34.3
Bidder E	58.3	37.1	33.3	32.8	33.9

The guarantees submitted on the 100-kw. units were as follows:

Loads	¼	½	¾	Full	1¼
Bidder A	62.0	44.0	39.9	39.7	41.4
Bidder B	60.0	42.0	36.0	36.0	37.5
Bidder C	72 0	45.0	38.6	38.7	42 0
Bidder D	52 7	38.5	34.7	34.0	34.9
Bidder E	59.6	37.3	33.5	33 2	34.2

It is thus apparent that the range in steam consumption is considerable, and to show what this difference in the steam rate really means, an analysis of one of the cases cited will be made. Take the engines offered the Bureau of Standards as an example. The price submitted by Bidder B was about $250 higher than that offered by Bidder A. Assume the engine to run ten hours a day, 300 days a year, operating at one-half load 25 per cent. of the time, three-quarter load 50 per cent. and full load 25 per cent. of the time. Assume the cost of coal to be $3.50 a ton of 2000 lb. and that a rate of evaporation of 7 lb. of water per pound of coal is obtained. The following tabulated results show the saving which would be effected by the more economical engine:

Loads	½	¾	Full
Bidder A's guarantee	26.1	25.0	25 6
Bidder B's guarantee	24.0	22.5	23.0
Difference, steam per i.hp.-hr	2.1	2.5	2.6
Time factor, per cent.	25	50	25
Saving steam per i.hp.-hr., lb.	0.525	1.25	0.65
Indicated horsepower	100	150	200
Saving steam per hour	52.5	187.5	130

Total saving steam per hour, lb.	52.5+187.5+130=370
Total saving steam per day, lb.	370×10=3700
Total saving steam per year, lb.	3700×300=1,110,000
Total saving coal per year, lb. (about)	1,110,000÷7=160,000
Total saving coal per year, tons	160,000÷2000=80
Total saving money per year	80×$3.50=$280

Operating under the assumed conditions, it is evident that the saving from the more economical engine would amount to $280 per year, provided the heating demands were not greater than the supply of exhaust steam with the engine operating at maximum economy. This would return to the investor 112 per cent. per year of the difference in price between the two engines. If the heating demands were in excess of the exhaust steam, the saving would be reduced. For at least six months of the year this excess demand would not obtain and the saving for this period would be 50 per cent. of the yearly amount.

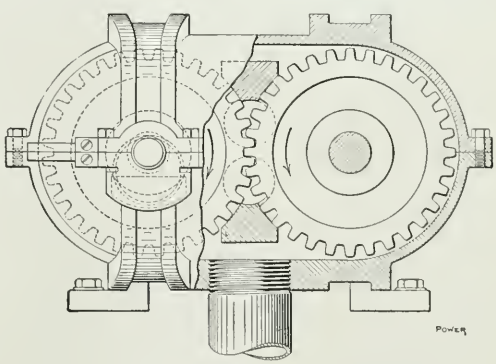
For approximately 60 per cent. of the heating period, the requirements would exceed the amount of steam exhausted and no saving over the less economical engine would be effected. The saving for this period would then be only 40 per cent. of half the total amount, or 20 per cent. of the total amount. The net yearly saving would then be 50 per cent. for the summer months and 20 per cent. for the winter months, or 70 per cent. of the total estimated amount of $280, which would be $196. This would yield 78.4 per cent. on the investment of the additional $250.

In the above calculations, the saving shown is in coal alone, and no consideration is given to the cost of the additional water, ash removal, etc., required for the less economical engine. These items would more than counterbalance any added interest charges on the initial cost.

In addition to steam economy, a more efficient engine will tend to give better operating results, and the cost of maintenance, due to the superior design, materials and workmanship which are usually responsible for a lower steam consumption, should be less. This would indicate that the strife for economy is well worth while, and that the engine with the lowest steam-consumption guarantee is the one to purchase, provided the guarantees made are bona fide and can be readily obtained in practice. In lieu of the requirement of an acceptance test with understood penalties for failure to meet the guarantees offered, it might be well to call for certified test data of similar engines operating under the same conditions. This data would at once show the possibilities of the particular make of engine to which it referred and would tend to prevent the selection of an inefficient engine, the loss from the use of which could not be offset by the penalty exacted.

The Clark Gear Engine

A new type of engine of simple construction has been designed by Charles H. Clark, of New York City. In its simplest form it consists of two intermeshing gears and two tapering blocks having curved faces close to, but not touching the teeth. One block is located above and the other below the intermeshing point, as indicated in the accompanying drawing. The blocks cover only small arcs of the gears and the larger parts of the gears are



Half Section through Engine

free to revolve in the casing. End plates between the blocks inclose the working section.

Depending upon which direction it is desired to run the engine, steam is admitted above or below the center line of the gears and pushing against the teeth at full pressure causes rotation. As the teeth pass the apex of the block small volumes of steam are inclosed and carried as far as its base, where exhaust to the casing and then to atmosphere takes places.

It is the wedge-shaped blocks which distinguish the present design from other types of rotary engine. Unbalanced pressure, due to high steam pressure over a large area of the gears and exhaust pressure on the other side, has been the bugbear of inventors. It must be borne by the shaft and tends to cause excessive friction and wear. In the Clark engine the small area exposed to unbalanced initial pressure of the steam practically eliminates this trouble.

In the single-stage unit it is evident that the expansion of the steam is not utilized. To get the benefit of expansion it is planned to compound the engine, using

several pairs of gears and exhausting from one to the other, the working volume increasing with a corresponding drop in pressure in each stage. As the number of stages increase, the economy is bettered. Basing his conclusions on results obtained from the simple engine, Prof. H. L. Parr, of Columbia University, estimates that a four-stage machine working between 100 lb. and atmosphere may be expected to develop a brake horsepower-hour on 30 lb. of steam.

A single-stage engine, rated at 35 b.hp. and in test developing 50, has been built and has been subjected to a number of tests, some at Columbia University and others at the New York Central power house in Yonkers. The best water rate obtained was 44 lb. per b.hp.-hr., when developing 46 b.hp. with an admission pressure of 97.5 lb. gage. With lower pressure the rate increased and at 10 lb. gage 94.2 lb. of steam per brake horsepower-hour were used. For intermediate pressures the rates varied between these limits. The floor space occupied by the engine was 2 ft. 11 in. by 2 ft. $11\frac{1}{2}$ in., which equals 6.2 sq.ft., or 0.18 sq.ft. per horsepower of rating. The total weight of the engine was 620 lb. complete.

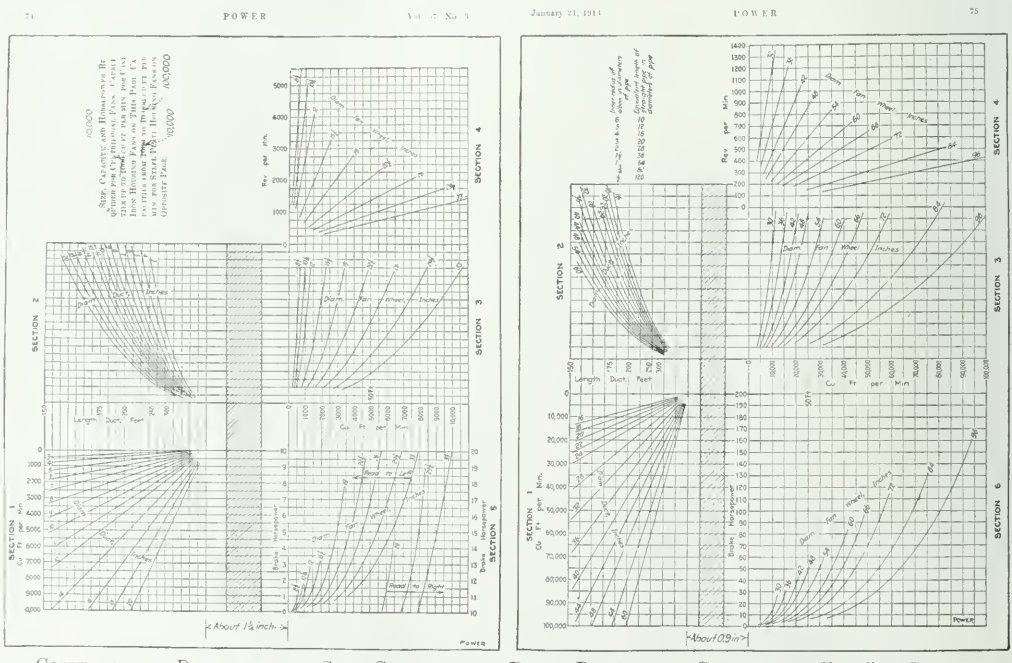
Size, Capacity and Power Required for Centrifugal Fans

In the article under the above title, in the issue of Jan. 21, 1913, an error was inadvertently made in the thought there was an unnecessary distance between the left- and right-hand halves of the diagrams on the two pages and so reduced the distance between sections 2 and 3, and between 1 and 5 on page 74. This space should actually be about $1\frac{1}{4}$ in. instead of about $\frac{3}{4}$ in. In the same way the distance on page 75 between sections 2 and 3 and between sections 1 and 5 was reduced. This distance should be about 0.9 in.

The readings for ducts 100 ft. long would be correct with the diagrams as they were printed, but where the process indicated by Fig. 2 in the article is carried out, for ducts 50 ft. long, the readings would be inaccurate. If these curves are used by any of our readers it will be well for them to cut the diagrams out, separate them and paste them together again the proper distance apart as indicated on the diagrams herewith.

Permutite, a Water-Softener

A new process for softening water has been introduced in Germany by Riedel & Cie Actien Gesellschaft, Berlin. In a filter apparatus about 3 ft. in diameter and 10 ft. in height is placed about two tons of a material, named "Permutite" by its inventor, Professor Gans, of Berlin. It is a silicate of aluminum and sodium and is obtained by smelting together clay, soda, silica and one or two minor substances. The result is an artificial zeolithe, that is, a silica of soda in which the sodium may be re-



Correction to Diagrams for "Size, Capacity and Power Required by Centrifugal Fans" as Printed in the Jan. 21 Issue. Shaded Areas Show Where the Diagrams Should Be Extended Horizontally

redrawing of the diagrams which formed pages 74 and 75 of the article.

Evidently the draftsman, with an eye to space economy,

placed by calcium, magnesia or manganese, if solutions of these metals are filtered through a bed of the substance. If a solution of calcium carbonate, for instance,

is filtered through the permutite, the latter retains the calcium and the water leaving the apparatus contains sodium instead.

An apparatus such as referred to is capable of softening 5500 gal. of water, showing a hardness of 18 deg., within an hour, or 66,000 gal. in 12 hr. After this time, it should be rested or rather regenerated. The process of regeneration consists in passing through the permutite a salt (NaCl) solution containing from six to eight times as much sodium as there was calcium and magnesium retained by the filter while softening the water. Once a month, however, twice that quantity of salt should be used to effect positive elimination of all calcium and magnesium salts.

Permutite has a shiny appearance, similar to mother of pearl, and is made in grains varying from 12 to 50 mesh, so that the surface, which determines the efficacy of the material, is relatively great. As, in the manufacture of the material, the soluble silicates are removed by treatment with hot water before the permutite is put into the apparatus, practically no loss of weight is encountered during service. A test made in a German factory showed a loss of weight of 5 per cent., or 198 lb., after one year of use.

Large National Heater

One of the largest, if not the largest, hot-water heaters ever built is herewith illustrated. It is of the U-bend type, Fig. 1, and has a capacity of 125,000 lb. of water per hour, heating it from 100 to 212 deg. F. with exhaust steam. It sets horizontally on cradles and is almost 9 ft. long, 5½ ft. in diameter, and contains two hundred and twelve 1¼-in. brass tubes expanded into a header.

Water enters at the front through an 8-in. inlet and

Fig. 1. Large National Heater

flows through a bank of tubes, passing longitudinally from front to rear, then to the front again, and again to the rear, making four passes before leaving through a water outlet of the same size, also at the front, Fig. 2. The water is compelled to travel through the tubes, as stated by baffles on the header. These baffles divide the space horizontally into two main sections, and other baffles divide the upper section into three parts and the lower section into two parts, as shown.

Steam enters a 10-in. inlet at the top and entirely surrounds the tubes, the condensate leaves the heater by a 4-in. drain at the bottom. All tubes are of brass. The steel-plate shell, does not corrode because it is not in contact with the water.

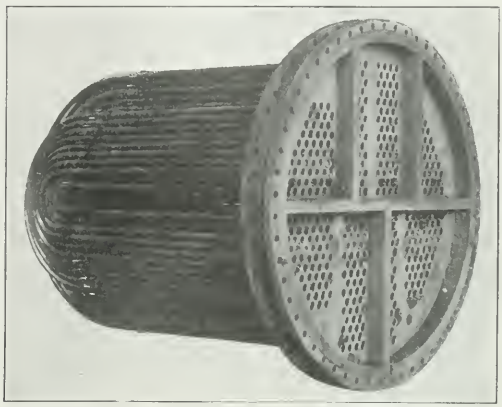


Fig. 2. Pipe Coils and Header Removed

The heater can be used as a storage heater by reversing the action, that is—directing the steam through the tubes which are then surrounded with water.

This heater is made by the National Pipe Bending Co., New Haven, Conn.

Turners Falls Hydro-Electric Development

Extensive developments are being planned by the Turners Falls Co., Turners Falls, Mass., near its present generating station on the Connecticut River, states the *Engineering Record*. The present station is rated at 7000 hp. and receives its waters through a canal which is diverted from the river above the town. This canal is to be extended more than two miles to Montague City, where a fall of 60 ft. will be obtained. A new dam, now in course of construction, will provide sufficient storage for the generation of 40,000 hp. during eight months of the year. The power developed at Turners Falls is sold to a number of allied companies which act as distributers.

A high-tension line from the station at Turners Falls is at present being built through Greenfield, Amherst and Chicopee, with a branch to East Hampton. The main line will probably later be extended across the Connecticut River through West Springfield. A substation is being built at Chicopee and the local distribution in the town and vicinity will be at 13,200 volts. The company is also building a substation at Amherst, which will be a sectionalizing station in the transmission line and will also contain transformers for local distribution by the Amherst Gas Co.

The power plant at Turners Falls will have a reserve in the steam plant of the Greenfield Electric Light Co. at Greenfield and one of the East Hampton Gas Co. at

Mount Tom. A 66,000-volt branch circuit will connect the Amherst substation with the Mount Tom steam station. The transmission line is complete as far as Amherst and will be finished to West Springfield in June. The Chicopee substation will be ready for operation about July 1.

Canadian Inspection of Boiler Construction

Boiler inspection standards and regulations will be uniform throughout the Canadian provinces, after July 1, as a result of negotiation between representatives from the different provinces, states "Engineering News." These regulations provide for the rigid inspection of all boilers during construction to see that proper materials and safe methods are employed. The object in making the regulations uniform is to insure a uniform degree of safety and to enable a certificate, granted in respect to a boiler in one province, to be accepted in any of the others.

To carry out the provisions of the act the province will be divided into districts with a chief inspector and two or three district inspectors. These inspectors will be given ample discretionary power in their work, with authority to insist on a proper standard of efficiency being maintained.

Hitherto there has been no such system of inspection. Steamboat and railway boilers are not included, as these are dealt with in a separate act. Once a boiler is inspected and installed it passes under the jurisdiction of the inspectors under the factories act. But where an old boiler is resold that has not been examined within one year of the time of sale, it may not be moved and applied to new work without a further inspection.

Directory of Commercial Organizations

In response to a Senate resolution passed in December, the Department of Commerce has submitted to the Senate a list of the commercial organizations in the United States. This record, with a list of agricultural organizations, will be printed for distribution, provision being made for 1500 copies for the use of the Senate.

The list of commercial organizations was prepared by the Bureau of Foreign and Domestic Commerce, which for nearly two years has been collecting for use in its own work detailed information regarding such organizations, their functions, membership, income, etc. The information in the files of the bureau at the time the resolution was adopted was supplemented by such additional facts as it was possible to obtain before Feb. 15, the date on which the list was to be submitted to the Senate, and this list when published will record about 3500 national, interstate, state and local organizations.

In the compilation of its information the bureau has utilized various symbols to indicate the field of service and the activities of the various organizations. These symbols have been used in the list submitted, so that when published it will furnish a complete record of the organizations. The information thus compiled constitutes a directory of commercial organizations of the country such as has never before been prepared and it should prove of practical value to business men.

In addition to the 1500 copies for the use of the Senate, the list will be issued as a bulletin of the Bureau of Foreign and Domestic Commerce (Miscellaneous Series No. 8). Copies of this bulletin will be sold for 15c. a copy by the Superintendent of Documents, Government Printing Office, Washington, D. C.

Allis-Chalmers Manufacturing Co.

Directors of the Allis-Chalmers Manufacturing Co., formed to succeed the Allis-Chalmers Co., met in New York on Mar. 17, and completed their organization by electing officers. John H. McClement, of New York, was made chairman of the board of directors, and Otto H. Falk, of Milwaukee, president of the company.

The executive committee chosen was Frederick Vogel, Jr., president of the First National Bank of Milwaukee; Gustave Pabst, chairman of the Pabst Brewing Co.; J. D. Mortimer, president of the Milwaukee Heat, Light & Traction Co.; Oliver C. Fuller, head of the Wisconsin Trust Co., of Milwaukee, and Messrs. McClement and Falk. The other directors are Max Pam and F. O. Wetmore, of Chicago, Arthur W. Butler, Charles W. Cox, Oscar L. Gubelman, R. G. Hutchins, Jr., Arthur Coppell, and William C. Potter, of New York, and James P. Winchester, of Wilmington.

A call is issued for the rest of the amount due on assessments as follows: On preferred stock $4 payable on Apr. 24, and $4 on May 15, 1913; on common stock, $2 on Apr. 24 and $2 on May 15, 1913. It is stated that the lines of manufacture which were produced by the old Allis-Chalmers Co. will be continued. The new company is capitalized at $42,500,000, and is said to have a substantial working capital through assessments on stock.

Engineering Students Make Annual Inspection Trip

The annual inspection trip of the senior mechanical engineering students of the Sheffield Scientific School, Yale University, began on Mar. 12 and lasted eight days. Visits were made to Holyoke, Schenectady, New York City, Hoboken, Harrison, N. J., Philadelphia and South Bethlehem, Penn.

At Holyoke the students inspected the water-power system and plant of the Crocker-McElwain Co., manufacturers of paper. Two days were spent at Schenectady, the first devoted to the General Electric Co.'s plant, the second to that of the American Locomotive Works. At the General Electric plant the students were the guests of the company at a luncheon given in their honor. The evening of the same day was pleasantly spent at a dinner in the Golf Club quarters at which the Yale alumni feasted the undergraduates.

In New York City the students were guests of the New York Edison Co., which took them about the city in sightseeing buses and treated them to a sumptuous luncheon at one of its substations. The Waterside stations were opened to the students for inspection, as were the Interborough station on Fifty-ninth St. and the new Grand Central Station.

The next few days were spent at the Keuffel & Esser Co.'s plant in Hoboken, the Henry R. Worthington Harrison plant, the Lardner's Point pumping station at Wissoning, Penn., the establishment of the Curtis Publishing Co., and the Cramp Co. shipyard in Philadelphia.

The big thing of the trip was a visit on the last day to the South Bethlehem plant of the Bethlehem Steel Co., where the students were shown through the plant, tracing its products from the ore to the finished piece.

Charters for 54 Electric Firms

Fifty-four electric companies in Allegheny, Westmoreland, Washington and Greene counties were chartered at Harrisburg, Penn., on Mar. 27, each with $5000 capital.

Thirty-one of the companies are incorporated by Arthur P. Dampman, H. W. Kalberer and W. E. Miller of Pittsburgh; seven companies by A. E. Dubois, Byron Trimble and C. W. Shock of Pittsburgh; 14 companies by G. F. Godshall, Henry Wharton and Spencer Ervin of Philadelphia, and one by W. B. Skelly, John W. Newmyer and A. F. Ramsey of Irwin.

Blowoff Pipe Pulls Out

On Mar. 19, two men were badly scalded in the boiler room of the Montrose Hotel, Cedar Rapids, Iowa. There are two 125-hp. return-tubular boilers in the plant, but only one of them was in operation and was carrying a pressure of about 90 lb. Suddenly the horizontal run of the 4-in. blowoff pipe pulled out of the elbow in the combustion chamber. The force of the steam and water blew open the firebox doors and scalded the fireman. Another man was working on the idle boiler and to get to the door had to pass through the escaping steam. He was also badly scalded, but both men will recover.

The pipe was not protected and had probably deteriorated, through the action of the gases, to such an extent that it could not withstand the working pressure. Another point worthy of notice is that if two doors had been provided in the boiler room, only one man would have been scalded.

Water power for cotton mills, to the extent of about 100,000 hp., has been developed in Georgia and the Carolinas, according to a report of the United States Geological Survey. Public service corporations in these three states are developing from 300,000 to 400,000 hp.

NEW PUBLICATIONS

DIE BERECHNUNG ROTIERENDER SCHEIBEN UND RINGE. NACH EINEM NEUEN VERFAHREN. By Max Donath. Julius Springer, Berlin. Pages 16; 6¾x9½ in.; paper; 5 illustrations and large folded chart. Price 1 mark.

In designing steam turbines, turbine pumps and all other machines of high rotative speeds, great care has to be taken in determining the inner strains of all revolving parts. The present method used necessitates an extensive knowledge of higher mathematics and has the disadvantage of taking considerable time.

In this little pamphlet the author develops what he claims is an entirely new method of calculating the proportions of such parts as disks and rings. He has simplified it enough for anyone possessing some knowledge of elementary algebra to be in position to do the work in relatively short time.

In the five chapters comprising the booklet, the author starts with the development of his new method and continues to show how, by means of his formulas and chart, disks of even thickness and disks of uniform strength radially can be easily designed.

Practical examples explain the method of finding general profiles of revolving disks as especially adapted for steam turbines. The whole is written in simple language and can be understood by any man with mechanical ability and a knowledge of German. This pamphlet should be useful to designers of steam turbines, turbine pumps, turbo blowers, etc.

BOOKS RECEIVED

COST REPORTS FOR EXECUTIVES. By Benjamin A. Franklin. The Engineering Magazine Co., New York. Cloth; 149 pages, 5½x8½ in.; plates; indexed. Price $5.

PRACTICAL MATHEMATICS FOR TECHNICAL STUDENTS. By Edward L. Bates and Frederick Charlesworth. D. Van Nostrand Co., New York. Cloth; 513 pages, 4¾x7½ in.; 325 illustrations; tables; indexed. Price $1.50.

PRACTICAL GEOMETRY AND GRAPHICS FOR TECHNICAL STUDENTS. By Edward L. Bates and Frederick Charlesworth. D. Van Nostrand Co., New York. Cloth; 621 pages, 4¾x7½ in.; 566 illustrations; tables; indexed. Price $2.

SOCIETY NOTES

The New England Society of Superintending Engineers held its regular monthly meeting and dinner at the American House, Boston, Mass., on the evening of Mar. 29. A number of prominent engineers were elected to membership. The business of the evening was taken up mostly in the framing of by-laws. It is the intention of the society at all future meetings to have papers on engineering topics read and discussed. President George W. Walsh presided.

On the evening of Apr. 2, the fourth annual banquet of the Northampton No. 3 Association, N. A. S. E., was given at the Draper Hotel, Northampton, Mass. The committee having the banquet in charge worked hard to make this year's dinner excel all former efforts. It included Chairman Day and R. P. Benedict, T. F. Butterworth, F. C. Howard, C. S. Clark, E. N. Krone and J. J. Brennan. A fine musical program was given by the Easthampton Mandolin Club, the Easthampton Male Quartet and the Northampton Glee Club. Among the speakers and entertainers were the Mayor of Northampton, W. H. Felker; Past National Presidents H. E. Stone and P. H. Hogan, State Vice-President A. M. Day and Jack Armour of "Power." Frank E. Davis was a most efficient toastmaster.

The following resolution by the American Museum of Safety trustees has been forwarded to President John H. Patterson, of the National Cash Register Co., Dayton, Ohio, in recognition of his heroic work among the flood sufferers: "Resolved, That the trustees of the American Museum of Safety by formal resolution desire to express their esteem and appreciation of the civic heroism and the unselfish devotion of John Henry Patterson, president, National Cash Register Co., one of the gold medalists of the Museum this year, in placing himself, his family, and his factory, unstintedly in the service of rescuing, sheltering, and feeding the afflicted in the great flood catastrophe overwhelming the city of Dayton. The trustees, furthermore, feel that this unselfish devotion and patriotic social service, typical of a long life devoted to social welfare, should not be accepted by the museum or the public in silence."

The annual meeting of the National Association of Cotton Manufacturers will be held at Boston, Mass., Wednesday and Thursday, Apr. 24 and 25, in Huntington Hall, Massachusetts Institute of Technology. The sessions will be called to order on Wednesday at 11 a.m. and 2:30 p.m., and on Thursday at 10:30 a.m. and 2:30 p.m. Governor Foss, a member of this association, and Richard C. Maclaurin, president of the Massachusetts Institute of Technology, have consented to give addresses of welcome. Senator John W. Weeks, an honorary member of the association, will also give an address if his duties permit him to leave Washington at the time. In addition to the opening address by President Edwin Farnham Greene, papers are expected on the following subjects among others: "Centralized Power Plants," "Economy in Lubrication," and "Economy of Superheated Steam."

OBITUARY

WILLIAM H. FLETCHER

William H. Fletcher, the vice-president of the W. & A. Fletcher Co., steamboat and steam yacht builders, and president of the Consolidated Iron Works, of Hoboken, who was a well known marine engineer, died Apr. 2 at his home, 777 West End. Ave., New York City. Mr. Fletcher was a member of many clubs and societies. He leaves a wife, one daughter and two sons.

PERSONALS

William Martin, for several years manager of the New York office of the Kennedy Valve Manufacturing Co., resigned that position on Apr. 1.

D. C. & William B. Jackson, the Boston consulting engineers for electric and allied properties, have moved from 84 State St. to 248 Boylston St., that city.

Frank Heimboldt, who for the past sixteen years has been chief electrician for the Prudential Insurance Co. at its home office in Newark, N. J., has accepted the position of superintendent of the Guaranty Trust Co. building, at Liberty St. and Broadway, New York City.

St. John (N. B.) Proposed Development

The New Brunswick (Canada) Hydroelectric Co. proposes to develop within 50 miles of St. John 15,000 to 20,000 hp. and transmit the current to the city to be used for light and power purposes. Legislation relative to street railways will result in an extension of the St. John Street Ry. system into the suburban districts, enabling the city to expand in these directions. This is considered important, as the present city is somewhat congested.

Cleveland Engineers Hold Smoker

On Saturday evening, Apr. 5, a smoker was held by National Association No. 5, of Cleveland, Ohio, at Elks Hall. About three hundred were present, including a large delegation from No. 47 of that city. Three of the national officers, James R. Coe, vice-president, Fred W. Raven, secretary, and Samuel B. Forse, treasurer, were in attendance, as well as R. G. Ingleson. Past President J. E. Radigan was the toastmaster.

Interesting addresses were made by the national officers and by F. R. Low, editor of "Power"; T. W. Roberts, past president of No. 47, and Mr. Osborn, president of the Central States Supplymen's Association.

The entertainment comprised numbers by Kenneth G. Merrill, William Murray, Fred Hickey, the Olmstead quartet and Jack Armour. A variety of refreshments was served. The committee included H. J. Baier, J. B. Lahiff, J. B. Clapper, E. E. Tindall, G. R. Henderson and Thomas Phillips.

Indiana Model Public-Utility Law

The Indiana public-utility law, which is effective after May 1, has been declared a model law in its clearness and practicability. The service commission created under this law will have five members, not more than three of whom will be of the same political party, and will be appointed by the governor for a term of four years. The duties of the former railroad commission are now assumed by the commission, which is authorized to employ such attorneys, engineers, examiners, experts, accountants, etc., as may be necessary.

Each public utility must furnish reasonably adequate service and facilities, and the charges shall be reasonable. Each must render to the commission uniform accounts of all business, and if engaged directly or indirectly in any other business shall make separate reports thereof if so ordered. The commission will prepare suitable blanks and forms for carrying out its purposes. No public utility shall keep any other books, accounts or records except those prescribed or approved by the commission, unless required by some other public authority.

Every public utility must carry an adequate depreciation account whenever the commission determines that it can be reasonably required. Depreciation charges shall be set aside out of the earnings and carried in a fund which may be expended either for new construction, extensions or additions to the property or may be invested; if invested, the income shall also be carried in the fund. This fund and its proceeds shall be used only for depreciation, and in no event shall the money expended from the fund for new construction be credited to the capital account, but it shall be charged against the depreciation fund.

No utility may charge or receive a greater or less compensation for any service performed by it than is specified in its public schedules. The commission shall provide for a comprehensive classification of the service rendered, which may take into account the quantity, the time, the purpose for which used and other reasonable considerations. The commission shall have authority to inquire into the management of all public utilities and obtain in any case all necessary information to enable it to perform its duties, including the right to inspect books, accounts, records, etc., and to examine under oath any officer or employee in relation to business affairs.

This commission is to have complete authority over the issues of stocks, bonds, notes and certificates of indebtedness by public-utility companies. No public utility shall issue any stock or certificate of stock except in consideration of money value, as found by the commission or at such premium as may be approved by it. When two or more corporations are merged the combined capitalization shall not exceed the sum of the capital stock of the corporations consolidated except for additional sums of cash actually paid out. No contract for consolidation or lease or merger shall be capitalized.

No license, permit or franchise will be granted to any interest to own, operate, manage or control any public utility in any municipality where one is already in operation and furnishes similar service under an indeterminate license, franchise or permit unless the commission has declared, after a public hearing, that the public interest requires a second utility and the resulting competition.

The act forbids any public utility to give free service, franks or special privileges to any patron or public officer, or to any political committee or candidate for public office. Violation of this provision is punishable by not less than one or more than five years' imprisonment, or by a fine of not less than $200 or more than $1000.

Rebates are declared unlawful. Violation of any of the provisions of the act by any officer or agent of a public utility is a misdemeanor and punishable by a fine.

The commission shall have the power to enforce the provisions of all other public-utility laws. A sum sufficient to carry out the provisions of the act, not to exceed $75,000, is appropriated annually out of the state treasury.

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NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being considered by the Beverly Gas & Electric Co., Beverly, Mass., for the improvement of its plant and extension of its system. A. Macauley is superintendent.

The city of Springfield, Mass., is considering plans for the construction of an electric-light plant to furnish light for the recently completed group of municipal buildings. John A. Dennison is mayor.

Preliminary arrangements are being made for the installation of an electric-light plant at Williams College, Williamstown, Mass., to furnish electricity for all the college buildings.

The Elmira Water, Light & R.R. Co. is preparing plans for the construction of a new power plant at Elmira, N. Y. H. M. Beardsley is manager.

Permission has been granted to the Public Service Electric Co. to construct an addition to its power plant on Duffield Ave., Jersey City, N. J. Estimated cost, $80,000. Dudley Farrand, Newark, N. J., is general manager.

SOUTHERN STATES

Plans have been prepared for the construction of a municipal electric-light plant at Camden, S. C. Estimated cost, $35,000.

Bonds for $30,000 have been voted for the construction of a water-works system at McColl, S. C. J. R. Bivens is mayor.

The city of Atlanta, Ga., is considering plans for the installation of an electric-generating plant at the river pumping station. Estimated cost, $9500. R. M. Clayton is chief of the construction department and R. C. Turner is city engineer.

The Washington Ice Co., New Orleans, La., is building a two-story brick addition to its factory.

An election will be held Apr. 24 by the citizens of Dresden, Tenn, to vote on the proposition to issue $24,000 in bonds for the construction of an electric-light plant.

The construction of an electric-light plant at Gleason, Tenn., is under consideration.

The Nashville, Chattanooga & St. Louis R.R., of which Horace Smith, Nashville, Tenn., is general manager, will purchase boilers for a small power plant it is to install at Paducah, Ky., for the operation of a round-house and machine shop it has recently built there.

The Park City Mills, Bowling Green, Ky., will buy electric motors for the operation of the special equipment, having decided to convert from steam power to the electric drive. Address R. D. McReynolds.

Ice machinery will be needed by the Fayette National Bank, Lexington, Ky., for its new 15-story office building, which is now being erected.

CENTRAL STATES

The village of Lindsey, Ohio, is making preliminary arrangements for the construction of an electric-light plant.

The Rubber Co. of Norwood, Ohio, will install five new boilers and an automatic stoker in its plant. Estimated cost, $25,000.

Plans have been prepared for the improvement of the municipal electric-light plant and system at Goshen, Ind. Estimated cost, $30,000. Burns & McDonnell, Scarritt Bldg., Kansas City, Mo., are consulting engineers.

WEST OF THE MISSISSIPPI

The construction of new municipal electric-light plant at Windom, Minn., is under consideration.

Plans are being prepared for the construction of an electric-light plant at Interior, S. D.

A company is being organized at Oacoma, S. D., for the purpose of constructing an electric-light plant. J. E. Kennedy is interested in the project.

The commercial club of White, S. D., is taking steps toward the installation of an electric-light plant and water-works system.

POWER

Vol. 37 NEW YORK, APRIL 22, 1913 No. 16

Look to Your Boiler Room

THE more complete and exact an engineer's knowledge is of the science of steam engineering the more successful he should be. The best surgeon is not always he who has the handsomest set of instruments but he who can use those which he has in the most skillful way. Likewise, the best engineer is not necessarily he who has the most pleasing looking plant but he who gets the best obtainable results with the apparatus he has charge of. And, other things being equal, the man who is best versed in the philosophy of the art will secure the best results, because he can test to find out whether the results he is getting are good, bad or indifferent. Thus, from his observations and by his knowledge he can diagnose the trouble when any is present and take the necessary steps to overcome it.

The boiler room has long been neglected. It is still left too much to take care of itself.

Engines fitted with suitable governors and given a rational quantity of lubrication will do their duty without any particular attention, and with economy which at least is uniform in degree. No need for personal manipulation to meet every slight variation of load or requirement—the engine responds automatically.

In the boiler room, however, things are different. Here, the personal element is a big factor. Intelligence and skill count for much. Yet, not only is the fireman often hired solely on his physical qualifications, but after he is hired, his work is usually but poorly supervised and his training is seldom thought of at all. As long as he holds the steam pressure where it belongs, he is not asked to do more.

Now, this is all wrong. The fuel is usually the biggest item in the cost of power generation. A dollar will buy so much coal. So much coal contains so much heat. After paying your dollars, why not use as much of the heat that you have bought as you possibly can? To burn coal so that the maximum of its heat will go into the water and form steam is a fine art.

Every engineer should know the limitations of his boiler equipment so well that he can get the best results under all conditions.

On page 582 of this issue we print the first of a series of articles dealing with boiler-room economy. These articles will tell "the whole story" from start to finish and will follow each other in logical order so that when the last one has been read—and digested—the reader ought to know all the fundamental facts about the economical combustion of fuel.

In this series the writer will take nothing for granted—everything, no matter how simple it may seem to some, will be fully explained. If you don't fully understand every statement made, don't let the matter slide. Write to us telling us just what it is you don't understand. Your letter will be treated with strict confidence and you will receive a prompt reply with the additional information needed.

Power Plant of Jacksonville Traction Co.

SYNOPSIS—A 2400-kw. reciprocating-engine power plant, generating electrical energy for street-car service. The engines operate condensing and are supplied with steam superheated 75 deg. F. Three 600-hp. water-tube boilers, designed to generate steam at 200 lb. pressure, are used.

Jacksonville, Fla., has a population of, approximately, 59,000 inhabitants and is well supplied with street-car service, the power to operate which is generated at the new power house of the Jacksonville Traction Co. This plant is on Riverside Ave., on the water front of the St. John's River. It is on a four-acre lot, graded to bring it above the water level.

Owing to the nature of the soil, it was necessary to drive about 1300 piles under the station foundation. The site, improved by filling in, is approximately 48,000 sq.ft. in area and reaches from the street to the water front. The building is a one-story structure of brick and steel with concrete footings, as shown in Fig. 1, and has a lawn in front.

Entrance to the engine room is through the engineer's office, at the right front corner of the building. There are two cross-compound engines directly connected to direct-current generators of 1200-kw. capacity each. The cylinders are 27x60x48 in. and a speed of 100 r.p.m. is maintained with 150 lb. steam pressure. These engines have covered tail rods, as shown in Fig. 2. Views of the valve gear of the high- and low-pressure cylinders of these engines are shown in Figs. 3 and 4. Three eccentries are used, one to operate the exhaust valves, one for the steam valves and a third to operate the valve-cutoff gear, thus relieving the governor of undue friction.

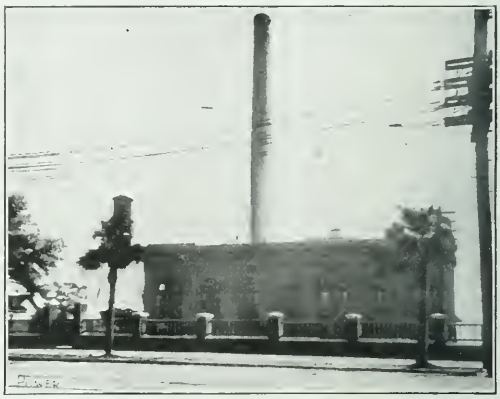


FIG. 1. POWER PLANT OF THE JACKSONVILLE TRACTION CO.

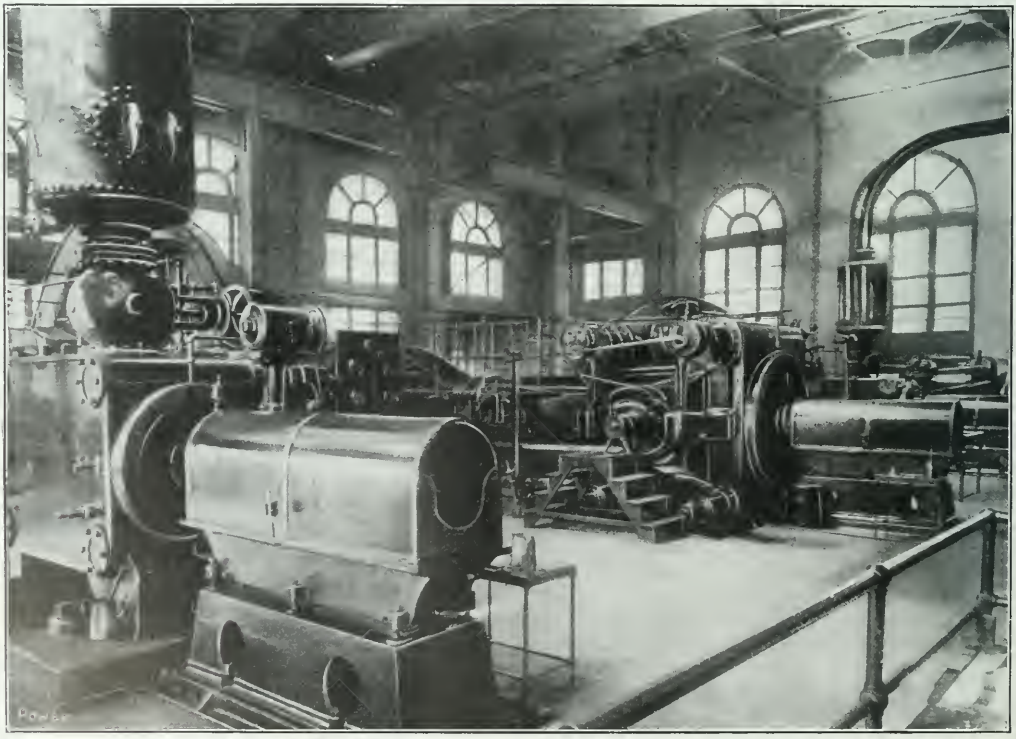


FIG. 2. VIEW OF THE ENGINE ROOM, SHOWING THE TWO RECIPROCATING UNITS

Steam is supplied through 6-in. steam pipes connected to a 12-in. steam header in the boiler room at the back of the boilers. Steam pipes drop down from the boiler outlets to this header, which is placed about 5 ft. above the boiler-room floor. A small 50-kw. unit, consisting of a three-phase, 60-cycle, alternating-current generator and exciter, is driven by a 600-volt direct-current motor, and used for station lighting.

Both main engines are lubricated in a manner not found in most plants. Instead of piping a lubricator to the steam pipe next to the engine, one is attached to each branch pipe leading to the engine, just above the main header. The oil-discharge pipes of the lubricator extend nearly across the steam pipe and are perforated on the top sides. This way of feeding the oil insures its being thoroughly mixed with the steam before it reaches the engine cylinders. The lubricating oil is returned to a filter of 150 gal. capacity per hour.

The main engines exhaust into two barometric condensers, which are between the boiler settings and the wall separating the boiler and engine rooms. Water is supplied to the condensers by two 12-in. centrifugal circulating pumps of 3000 gal. per min. capacity, which are directly connected to 8x11-in. horizontal engines. The water comes to the pumps through a 7½x5-ft. intake 725 ft. long, extending from the power house to the river front, 12¼ ft. below the low-water level. The intake screen walls, constructed of reinforced concrete, extend 17 ft. below the low-water level. A double tunnel of reinforced concrete runs through the building and extends 12 ft. back of it, 15 ft. below the low-water level.

Pumps

All pumps are in the basement under the engine room. The two rotating, horizontal, dry-air, vacuum pumps are 10 and 18 by 18 in. in size. The two 14 and 8½ by 15-in., duplex, center-packed, plunger, boiler-feed pumps,

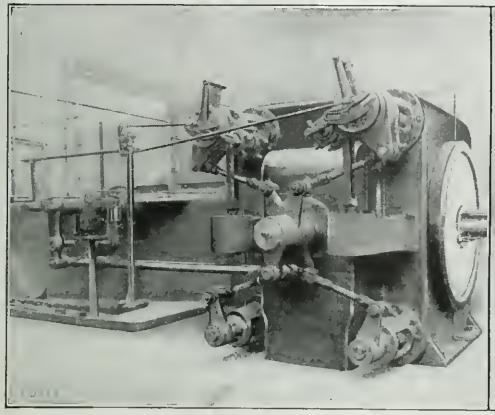


Fig. 3. Low-Pressure Valve-Gear

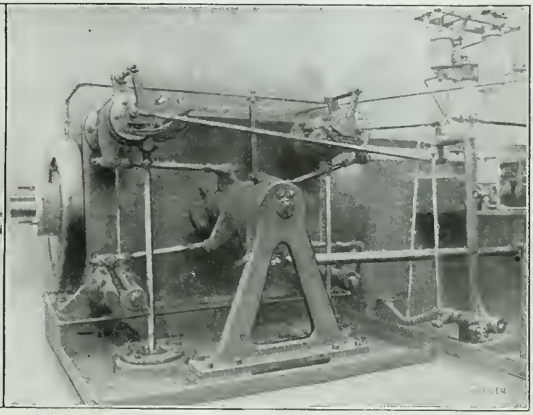


Fig. 4. High-Pressure Valve-Gear

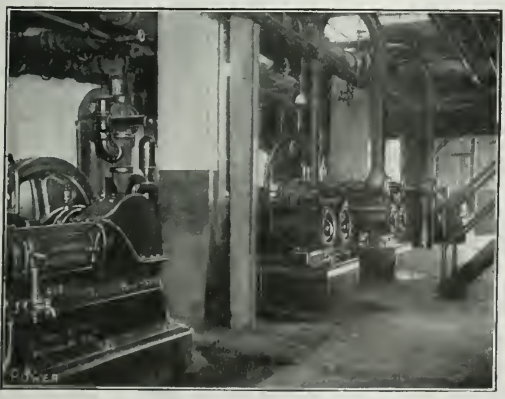


Fig. 5. A Portion of the Pump Room

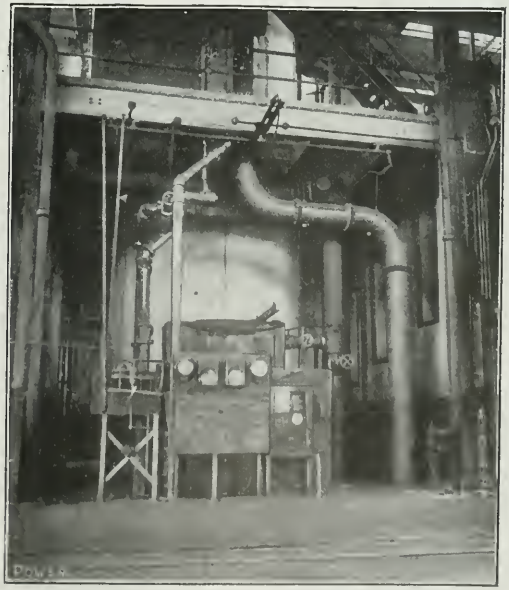


Fig. 6. Heater, Receiving Tank and Water-Recording Meter

with a capacity of 250 gal. per min. each, are about midway of the pump room, as shown in Fig. 5. There is also one 7½ and 8½ by 10-in., duplex, low-service pump, with a capacity of 250 gal. per min., and one 2-in. centrifugal, low-service pump, of 100 gal. per min. capacity, directly connected to a 7½-hp., 600-volt motor. An 18

FIG. 7. PARTIAL VIEW OF THE BOILER ROOM

and 10 by 12-in. underwriter's fire pump, with a capacity of 1000 gal. per min., is at one end of the pump room. This room also contains a 9½ and 13 by 10-in. air compressor, with a capacity of 92 cu.ft. of free air per min.

boilers, as shown in Fig. 6. A 9x200-ft. reinforced-concrete chimney stands between the two sets of boilers. The 3000-hp. open heater is on a platform level with the top of the boilers; the exhaust pipe from the auxiliaries en-

FIG. 8. UNLOADING COAL FROM A SCHOONER

ters it at the end. The return and cool makeup-water tank is on the boiler-room floor below the heater, and in front of it are the damper regulator and water-recording meter, the latter having a capacity of 125,000 lb. per

EQUIPMENT OF THE JACKSONVILLE TRACTION CO.'S POWER PLANT

No.	Equipment	Type	Purpose	Kw.	Volts	Hp.	R.p.m.	Size	Steam Pres. lb.	Maker
2	Engines	Corliss	Main units	1200			100	27x60x48″	150	Nordberg Mfg. Co.
2	Generators	Direct current	Main units	1200	600		100			General Electric Co.
2	Condensers	Barometric	Engines					57″		Mesta Machine Co.
3	Boilers	Water tube	Steam gen.			600			150	Edge Moor Iron Works
2	Pumps	Duplex	Boiler feed					14x8½x15″	150	Henry R. Worthington
1	Pump	Duplex	Low service					7½x8½x10″	150	Henry R. Worthington
1	Pump	Centrifugal	Low service					2″		Henry R. Worthington
1	Motor	Direct current	Centrifugal pump		600	7½				General Electric Co.
1	Heater	Open	Feed water			3000				Warren Webster & Co.
2	Pumps	Centrifugal	Circulating					12″		Alberger Pump & Condenser Co.
2	Engines	Horizontal	Cir. pumps					8x11″		Alberger Pump & Condenser Co.
2	Pumps	Horizontal rotative	Dry vacuum					10x18x18″		Alberger Pump & Condenser Co.
1	Pump	Underwriters	Fire					18x10x12		Henry R. Worthington
1	Water softener	Kennicott	Feed water					10,000 gal per hr.		Kennicott Water Softener Co.
1	Recorder	Lea	Feed water					125,000 gal. per hr.		Yarnall-Waring Co.
1	Stack	Concrete	Smoke					9'x200'		General Concrete Construction Co.
2	Pumps	Duplex	Oil					3½x2½x4″		Henry R. Worthington
1	Compressor	Westinghouse	Air					9½x13x10″		Westinghouse Air Brake Co.
1	Crane	Motor travel	Engine room					30 ton		Niles-Bement-Pond Co.
1	Scale	Track scale	Coal					36'		Fairbanks Co.
1	Filter	Fleur-de-lis	Oil					150 gal.		Boston Steam Specialty Co.

Two 3½ and 2¼ by 4-in. duplex oil pumps handle the oil used in the engine-lubricating system.

BOILER ROOM

Three 600-hp., water-tube, hand-fired boilers, each equipped with a superheater, supply steam at 150 lb. and 75 deg. superheat. The tops of the boiler settings are flat, with concrete filling, and a concrete platform is built between the single boiler setting and the battery of two

hr. This arrangement centralizes all of the boiler-room apparatus at one point, convenient for observation and attention. Fig. 7 is a part view of the boiler room.

In the yard is a 30,000-gal. overhead fire tank, with a head of 90 ft. and a 30,000-gal. overhead water-storage tank, with a head of 60 ft. Both tanks are supported by the same structural work, as shown in Fig. 1.

All feed water is treated in a water-softening plant, having a capacity of 10,000 gal. per hr.

Coal is shipped to the plant by water and unloaded into a car by a steam-driven locomotive crane, Fig. 8, having a capacity of 17 tons per hr. at a 10-ft. radius. When the coal car is loaded the locomotive crane draws it the length of the 380-ft. wharf to the 4000-ton coal-storage space, outside the boiler house, where it is unloaded from the car by the crane and clam-shell bucket to the storage pile, or is unloaded at the boiler house into a small coal hopper. Under the latter the boiler-room firing car is run, loaded and, after being weighed on a track scale, pushed to any boiler.

The average coal consumption is 2.24 lb. per kw.-hr. for a 24-hr. run. A better showing than this would be made were it not for the inefficient load between 12 midnight and the time of the heavy morning load. The average load for the 24 hr. is 2300 kw. A reproduction of the log sheet used at the plant is given in Fig. 9.

Nine years ago a 250-kw. unit was sufficient to handle the street-car service for the city. Then a 300-kw. unit was added, and, five years ago, an 800-kw. unit was installed in the old plant. The present plant, it is estimated, will supply the city with street-car service for 100,000 inhabitants. The ultimate capacity of the plant will supply the needs of 400,000 population.

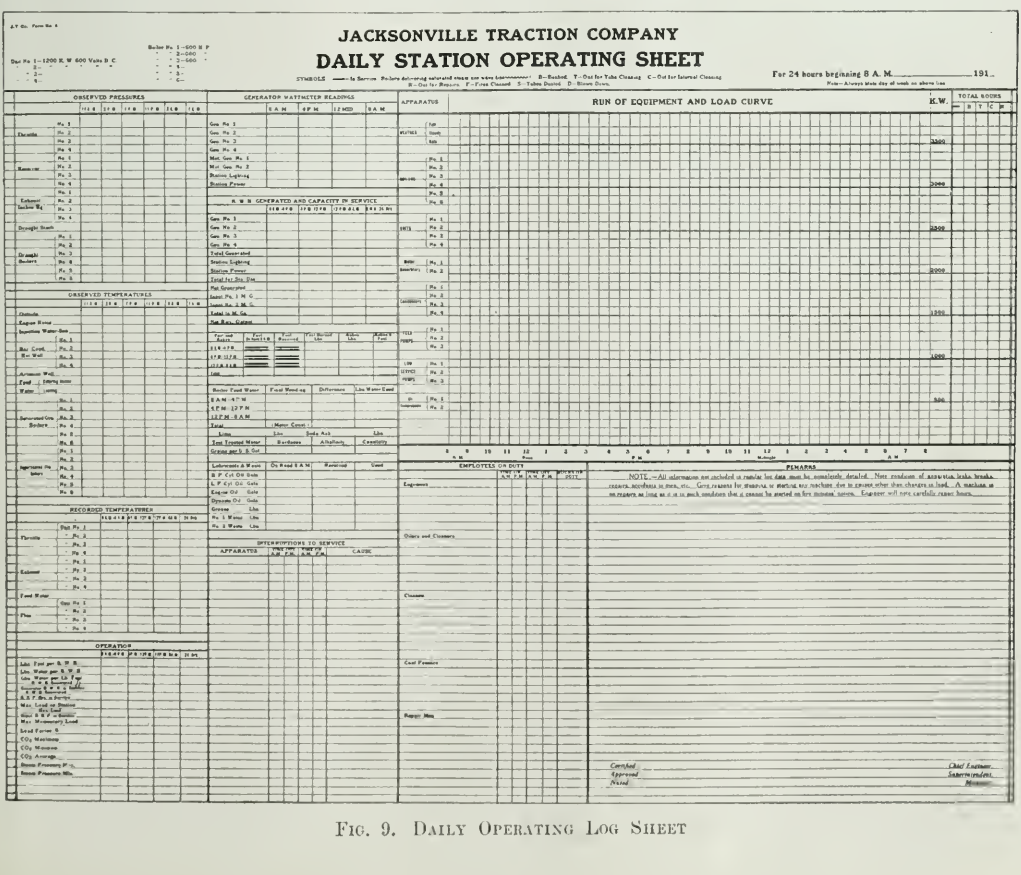
Actual work of excavation for this plant began Apr. 3, 1911, and on Nov. 1, of the same year, one engine was started noncondensing. On Feb. 10, 1912, the station was ready to deliver power with the No. 1 engine running condensing, and, on the 26 of the same month, the plant was turned over to the operating company, complete.

Power Plant of Elgin Watch Factory

The fact that the Elgin Watch Factory at Elgin, Ill., has its own private power plant has made some very interesting "copy" for the advertising manager of their well known product. Recent advertising of the Elgin company gives a description of its large new plant.

Steam is generated in a battery of four boilers which are equipped with self-stoking grates. There are two engines, one of 300 hp. and the other of 750. Direct connected to these engines are three generators. There are also one steam- and one motor-driven exciter, an air compressor and a refrigerating system. The switchboard is heavily equipped and consists of 14 panels.

The electrical power generated is supplied to every room in the factory by motors which move 12,499 ft. of main shafting, 13,747 ft. of countershafting and 73,837 ft. of belting. The lamps lighted throughout the building total to 7000. The exhaust steam is, of course, used to heat the entire establishment. The Elgin plant in every way shows the progressiveness of its owners.—*The Isolated Plant.*


JACKSONVILLE TRACTION COMPANY

DAILY STATION OPERATING SHEET

Fig. 9. Daily Operating Log Sheet

Pipe Sizes and Steam Velocities

By C. W. Ham

SYNOPSIS—Discussion of the determining considerations in selecting sizes for high-pressure piping in power stations and velocities of steam. The basis should be a compromise between radiation and friction losses and generally higher than common velocities are allowable. Steam outlets or openings on equipment are not safe guides to proper pipe sizes.

While piping is a small part of the station and was formerly considered relatively unimportant, it has become a leading subject for study in connection with power-station design. There seems to be no fixed basis for the design of high-pressure piping, and, while the subject of pipe sizes and velocities of steam has been much discussed recently, opinions still differ considerably as to what constitutes best practice.

Steam piping both for high-pressure and auxiliary lines, is generally unnecessarily large. Formerly it was thought that piping could not be too large, and as engineers were averse to taking the responsibility for small piping they specified liberal sizes.

If a pipe is too large the radiation loss will be excessive; on the other hand, because of friction, a pipe may be so small as to cause a too great drop in pressure. Pipe diameters should, therefore, be a compromise between the radiation and friction losses. In steam-turbine practice, a drop in pressure of 5 to 10 lb. between boiler and turbine is permissible. Increasing the pipe size reduces friction so little and adds to radiation loss so much, that the tendency lately to adopt smaller pipe and greater steam velocity is justified, both from the operating side and that of first cost. The gain from the operator's standpoint is chiefly in flexibility. This means less strain on the fittings because of easier expansion and contraction, with smaller cost for repairs. Vibration, sometimes resulting from small diameters and high velocities, can be overcome by avoiding too many sharp turns. The tendency toward larger units in power stations and high pressures and superheat requires that the piping be large and of high-grade material, and the cost increases rapidly with the size. For example, a 9-in. high-pressure fitting costs about 25 per cent. more than an 8-in. fitting. Size is, therefore, of considerable importance in the cost of an installation.

The advent of the steam turbine, with high pressure and superheat, revealed the fact that different standards are demanded in pipe diameters. In a steam-engine plant, shocks due to the intermittent demand for steam must be allowed for and the piping has usually been made large enough to act as a reservoir for handling large amounts for short periods. Making the pipes smaller and having a receiver near the engine would be better and is sometimes done. Conditions are different with turbines, because steam is delivered to them steadily. An authority has declared that if, instead of turbines, reciprocating engines were operated, using superheated steam, the pipe line would have to be of approximately 25 per cent. greater area, and, if the reciprocating engines used nonsuperheated steam, it would have to be 40 per cent. larger.

The most marked revolution in the design of steam piping has been in the design of the header. Formerly it was customary, in using the header as a reservoir, to make it equivalent in sectional area to the sum of the areas of the boiler outlets. This often led to absurdly large sizes and low velocities, not only because all the steam from the boilers does not necessarily pass through any one section of the header, but also because the standard boiler outlets have been unnecessarily large, their sizes being governed by shop standards rather than by any fixed velocity. For example, there are 300- and 600-hp. boilers having the same size nozzles. As it has been the custom never to reduce the steam pipe below that called for by the nozzle on the boiler, it can be understood that headers proportioned on that basis frequently led to absurd results. Rarely is it possible to place the header near the prime movers. If this is practicable, the larger header is justified and becomes of value as a receiver. In latest practice, however, the header is made little if any larger than the branch pipes leading from it; the size being governed by the maximum amount of steam passing any one section, just as with other piping.

Important in the design of piping, and the chief factor in fixing the proper size, is the

Velocity of Flow

Until quite recently a steam velocity of 5000 ft. per min. was considered high, and most piping was based upon even lower velocities. The maximum permissible velocities are now quoted by most authorities at from 6000 to 9000 ft. per min., and during heavy overloads for short periods, 10,000 to 12,000 ft. per min. It has been demonstrated that the higher velocities are satisfactory, and that the radiation losses are thereby greatly reduced, especially with highly superheated steam.

In some of the large latest turbine stations the piping size is based on a velocity of approximately 8000 ft. per min., with a pressure drop of 5 to 10 lb. from the boiler to the turbine. This seems to be the velocity sanctioned in the most uptodate work where high pressure and superheat are common. The velocity of exhaust steam ordinarily varies from 20,000 to 30,000 ft. per min., depending on the vacuum carried. On account of the very rapid increase in the volume of steam for slight increases of high vacuum, exhaust steam may, in extreme cases, reach much higher velocities. As the time the peak load is carried is usually short, to keep the pipe sizes down, efficiency might well be sacrified during those periods and extreme velocities employed.

In spite of these higher velocities being advocated by good authorities, many modern power stations do not use the higher velocities. This is partly because builders of boilers and prime movers have made their steam connections ample, generally giving the purchaser the size called for. Many engineers and operators being still prejudiced against small piping, large sizes are specified. The piping is connected up without any reduction, hence the low velocities. For a number of years a certain boiler was operated with an 8-in. pipe leading from it, which was replaced by a 5-in. pipe, giving entirely satisfactory

results. Lately boiler manufacturers have realized that their standard nozzles are too large and are having them reduced. Even then they are governed more by a question of standard than velocity, so the matter of pipe sizes should be considered independently from the sizes of nozzles proposed by boiler manufacturers.

The sizes of standard steam openings in power-plant units are based upon some assumed condition of the steam at a moderate steam velocity. Then for the sake of standardization, a definite size of opening is assigned to cover a certain range in size of units. Openings are thus the result of a practical compromise to suit numerous conditions, consequently it is not reasonable to assume that, in specific cases, the piping should be made to conform to the standard openings.

Comments on Table

In the accompanying table are given the size of main steam piping, velocities of steam, and drop in pressure in a number of modern steam-turbine stations selected at random. The velocity quoted is based on the maximum continuous output capacity of the plant; that is, the velocities that exist in the piping system when the units are operating at the load that can be maintained continuously. This average condition would ordinarily mean about 50 per cent. overload on the boiler and full load on the turbine. What are usually called extreme velocities may be estimated on the basis of 100 per cent. overload on the boiler and 50 per cent. overload on the turbine. It would be unfair to base them on the very large momentary overloads which are not maintained for any considerable time.

In no case does the drop in pressure exceed 10 lb. Any greater drop during temporary overloads could be overcome if necessary, as with modern boilers it does not cost must to increase the steam pressure sufficiently to compensate for the drop due to high velocities.

Examination of the table will show that, although high pressures and superheat are employed, most of the piping systems have been laid out along much the same lines as in previous practice. The velocities are low and vary widely, and there is no uniformity, even in the same system. For example, in Station No. 3, the velocities in the boiler and turbine pipes are low, while that in the header is extremely high. Plainly, velocities were not considered in the design; the piping having been simply made the same size as the nozzles on the machines. However, the tendency toward the smaller header is strikingly brought out. In no case has a reduction been made at the nozzle.

In Station No. 2 the boiler pipe has been actually increased. In the examples given here where the piping system is based upon high velocities, the designer has specified small steam openings for the units, which can nearly always be done, instead of using a reduction fitting.

In Station No. 1, instead of working up the piping plans, as usual from the boiler nozzles toward the generating apparatus, the designer started at the turbine where the steam is to be used and worked toward the boiler, having the boiler manufacturer put on nozzles to suit the piping arrangement. No particular attention was paid to velocity in any particular part of the line. The turbine opening was of such size as to give a high velocity in the turbine pipe. The velocity in the rest of the system is somewhat lower, but, on the whole, high as compared with many other stations. This is a typically modern station, and the piping is noteworthy in that it was one of the first installations recognizing the fact that turbines demand smaller pipe diameters.

In No. 4 the designer allowed for superheated steam permitting higher velocities than with saturated steam, there being considerably less friction, and the volume of steam at 175 lb. pressure and 150 deg. superheat being about 30 per cent. greater than saturated steam at the same pressure. The table shows the velocities to be fairly uniform, in the system, and considerably above the average. Station No. 6 is typical of the use of high velocities and the piping in this plant is giving entire satisfaction.

The striking feature of Station No. 12 is that it is the only one of the group in which velocity was made the basis for the design of the entire piping system. Here the velocity is high, 7900 ft. per min., and uniform throughout. This plant is of very recent construction, is operating satisfactorily, and the design of the piping system may be taken as typical of the very latest and best practice.

TABLE SHOWING SIZE OF PIPING, VELOCITIES OF STEAM, AND DROP IN PRESSURE IN 12 STEAM-TURBINE POWER PLANTS UNDER NORMAL WORKING CONDITIONS

	Station	Rating of Units								Boiler		Header		Turbine		
								Steam Consumption of		Steam Pipe				Steam Pipe		
No.	Normal Capacity in Kw.	Boiler Hp.	Turbine Kw.	Steam Pressure Lb. per Sq.in.	Superheat, Deg. F.	Feed Water, Temp. Deg. F.	Vacuum, Inches Mercury	Turbine, Lb. per Kw.-hr.	Dia. Boiler Nozzle	Dia. In.	Vel., Ft. per Min.	Dia. In.	Vel., Ft. per Min.	Dia., In.	Vel., Ft. per Min.	Drop in Pressure, Lb. per Sq.in.
1	15,000	625	5000	200	0	210	28 0	17 0	6	6	5600	8	6,300	9	7000	10
2	6,000	600	3000	200	100	200	28 0	14 7	8	10	3750	12	6,750	10	3500	10
3	11,000	600	1500	175	100	210	29 0	20 0	8	8	4200	12	11,400	8	4300	10
4	20,000	600	5000	175	150	205	29 25	17 0	7	7	6000	16	7,500	12	5900	10
5	2,000	500	1000	175	0	265	28 0	21 0	8	8	3300	15	4,800	7	3400	5
6	30,000	300	3500	175	125	200	27 0	16.0	4	4	8700	20	7,700	12	3700	5
7	5,000	600	2500	175	125	210	27 0	15.8	6	6	7650	10	5,400	10	3700	10
8	1,000	400	800	160	100	205	28 0	18 0	7	7	4200	12	4,200	7	3250	5
9	3,000	585	1500	160	175	212	28 5	22 9	6	6	9000	8	5,000	8	6200	7 5
10	8,000	500	2000	200	200	210	29 0	18 5	8	8	4000	12	6,300	9	4250	5
11	1,500	150	500	145	0	196	28 0	21 6	6	6	1900	12	4,000	5	4100	5
12	8,000	190	750	160	125	200	28.0	16.7	4	4	7900	10	7,900	4 5	7900	10

There is a strong tendency now to dispense with a lot of countershafting formerly used in driving woodworking machines, and it is the electric motor and the high-speed lineshaft that are doing it. It is easy to understand the high speed and light sizes in connection with electric motors, but even among those not using motors there is the same tendency to use lighter lineshafting and run it at higher speed. It helps reduce the friction load by making the shafting and pulleys lighter, the belts smaller and the strain or pull less.—"Woodworker."

There are between 9,000 and 10,000 passenger elevators and 12,000 freight lifts in Manhattan alone which carry about 6,500,000 persons each day. In the six years from 1903 to 1908 more than 4,000 elevators of all makes were installed and in the period 1903 to 1907 there was an increase of rentable area of 23,870,006 sq.ft., or about 550 acres, of which 6,772,006 sq.ft. were business buildings, 10,965,835 sq. ft. were lofts and stores and 3,178,243 sq ft. were in factories.

Peculiar Explosion of Locomotive Boiler

SYNOPSIS—A locomotive boiler explodes while standing on a siding, killing the engineer and wounding the fireman. The boiler, intact, is blown 100 ft. away. The curvature of the crown-sheet is reversed and the stay-bolts are not even bent. Low water undoubtedly the cause of the explosion.

While standing on a siding at Handley, Tex., Mar. 30, the boiler of engine No. 325 of the Texas & Pacific R.R. exploded, instantly killing the engineer and wounding the fireman and another workman.

The recoil action as the boiler leaped forward. The tender and front end of the locomotive were but slightly damaged (Fig. 3), which shows that the force was greatest at the rear and acted downward almost entirely. The track under the truck was also torn from the ties and bent badly, as shown in Fig. 2. This was evidently caused by the movement of the disconnected driver as it was thrown outward.

The crown-sheet was ripped almost entirely from the boiler, as shown in Figs. 4 and 5. The curvature of the crown-sheet was reversed as it was blown down through

FIG. 1 DAMAGED TRUCK AND BOILER FIG. 2
FIG. 3 FIG. 4

As shown in Fig. 1, the boiler was blown completely off the trucks, landing on the track about 100 ft. ahead and finally coming to rest in the position shown. How severely the trucks and mechanism carried thereon were damaged may be seen in Fig. 2. Some idea of the force of the explosion may be gained by a glance at the severed driver in this illustration. The rod connecting this driver remained intact at the head end, and acted as a pivot around which the driver was caused to rotate through an angle of a little over 90 deg.

The damage to the trucks was undoubtedly done by the firebox. From the smoothness of the curvature it would seem that the sheet was very hot when the explosion occurred; otherwise the bottom of the sheet would have bent more irregularly. That part of the sheet immediately over the grates was discolored, showing that it did heat considerably. Another thing that indicates that the sheet was quite hot is the manner in which it parted from the stay-bolts, none of which were torn from the sides or top of the firebox.

It looks as though the heads of these bolts became red hot, thus allowing the crown-sheet to slip over the soft-

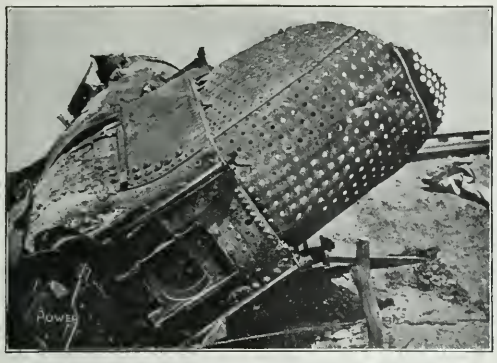


Fig. 5. Crown-Sheet; Curvature Reversed

Fig. 6. Front End of Boiler

ened bolt heads without cracking the sheet or disturbing the other ends of the bolts. Another interesting peculiarity is that hardly any, if any at all, of the bolts were even bent. The tubes were damaged but little. The bent sheets at the front end, as shown in Fig. 6, were damaged chiefly by the boiler falling on that end as it landed on the tracks after having turned over a couple of times in the air.

Examination of the firebox showed that the boiler was coated with scale, but not unusually so. Only one gage-cock could be found and that was clear and in working condition.

There was no indication of heating at the place where the crown-sheet ripped, but its discoloration in the center indicates low water. As far as is known the safety valve was in working order.

Slinging and Making Hitches*

By John Riddell†

SYNOPSIS—Suggestions for the avoidance of accidents when handling heavy machinery with a crane. A number of hitches are also illustrated.

There is a great difference in ropes and slings used for hoisting. The wear in ropes can always be seen by the strands becoming frayed, loose or cut; whereas a chain, outside of a few bruises, will not show any signs of weakness, although actually it may be full of small cracks which cannot be seen by the naked eye, or it may be crystallized by long use. A chain under these conditions rapidly becomes weaker with each lift, until it finally gives way.

Suitable racks should be provided for hanging chains and slings when not in actual use. These slings should be inspected frequently to detect weakness, sorting out the bad ones and having them repaired.

There are many varieties of hitches and many kinds of knots. Some are useful, others are ornamental; only the useful kind will be considered. A general description is given of the standard hooks, eyes, clevices, etc., used in general practice. Some knots and hitches are shown which are used in special cases, but which are not intended for everyday use. They are useful, however, for riggers, millwrights and others handling special machinery and materials, and should be used only by men competent in such work.

A wire cable sling should never be used singly when hooked by a spliced eye. When the weight is sufficient the cable is likely to untwist, thus allowing the splices to open and slip. Such slings should always be used double, and where sharp corners or rough castings exist the cable should be protected by pads.

In using slings of any kind, especially rope, care should be taken to see that one rope does not lie on top of the other, as this will prevent proper equalization, putting undue strain on the outer rope. Often when a rope sling is used double, the ends are passed through the doubled part, as when placed around a casting; and, unless this is done carefully, instead of having the strength of two parts of a rope, as supposed, it can be so slipped around the piece being lifted, as to actually have the strength of only one part.

Sudden Stoppage of Load

Before lifting heavy loads by means of a crane the crane brakes should always be tested to see that they are in good condition and will hold. Care must be used when lowering loads, to limit the speed, which should not exceed the hoisting speed of the crane for the same load. Particular care must be taken to apply the brakes gradually when bringing the load to rest. The ordinary hoisting speed for a 30-ton motor-operated crane is about 18 ft. per min., and for a 50-ton crane about 12 ft. per min. with the rated load. Sudden stopping at such speeds may double the stress on the slings and crane. This point cannot be emphasized too strongly, as serious accidents have resulted from the sudden stopping of cranes while the load was being lowered.

When a weight is lifted by two or more slings connected to the crane hook and making an angle with each other,

*From an article in the "General Electric Review."

†Mechanical superintendent, Schenectady Works, General Electric Co.

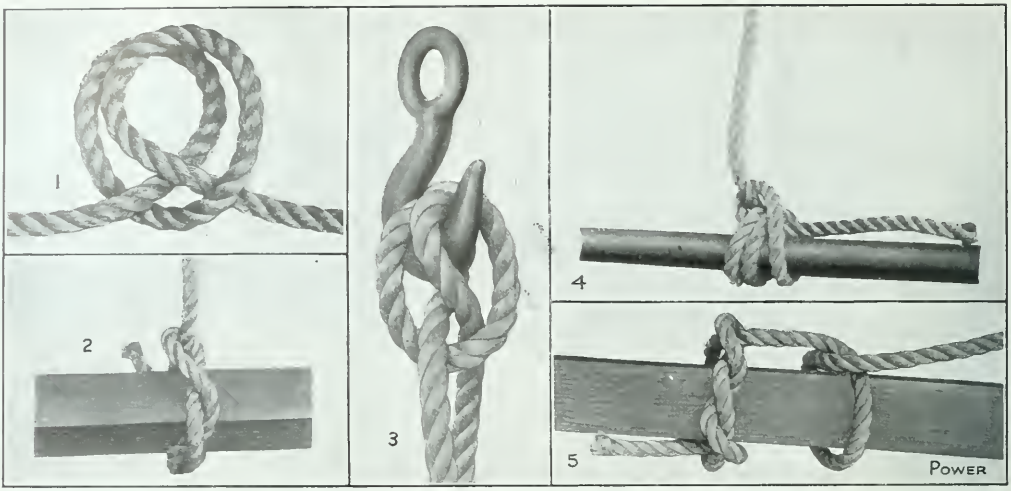


Fig. 1. Clove or double half hitch. Fig. 2. Timber hitch. Fig. 3. Clove or double half hitch adapted for hauling. Fig. 4. Studding sail hitch, useful in hoisting timber. Fig. 5. Timber and half hitch, useful in hoisting shafts or timbers in vertical position.

the increase in the stress of the individual slings must be considered. On account of this angle between the two sets of slings the stress on each set is greater than half the total load, and increases very rapidly as the angle between the sling and the work is decreased. An angle of 45 deg. between the sling and the work makes the

TABLE 1. SAFE LOADS FOR EYE-BOLTS

	Inches A	Inches B	Inches C	Safe Load, Lb.
Drop-forged steel.....	½	1¼	7/16	1,100
	⅝	1⅝	9/16	1,500
	¾	1¾	5/8	1,800
	⅞	1¾	⅝	1,800
	1	1¾	⅝	2,800
	1	1¾	¾	2,800
	1	1¾	⅞	3,900
	1	2¼	⅞	3,900
	1	2¼	1	5,100
	1¼	2⅝	1⅛	8,400
	1¼	2⅝	1⅛	8,400
	1½	2¾	1¼	12,200
	1½	3⅛	1¼	16,500
	2	3⅛	1⅜	21,800
D.B.G. Iron E.L., 28,000 lb. per sq.in., welded	1¼	3	1¼	10,000
	1½	4	1½	11,000
	2	5	1¾	14,000
	2½	6	2	16,000

stress in each sling three-fourths of the total weight, and the collapsing force between the two points of attachment to the work is equal to half the weight. This collapsing

TABLE 2. WEIGHTS OF VARIOUS MATERIALS

Material	Weight per Cu.Ft., Lb.	Weight per Cu.In., Lb.
Cast iron	450	0.26
Steel	489	0.28
Copper	552	0.32
Lead	709	0.41
Wood		
Ash	45	
Pine	38	
Concrete	155	
Stone	180	
Earth	72 to 110	
Brick	100 to 150	
Mortar	100	
Marble	180	

Shafts

Diameter, In.	Weight of Shafting in Lb. per Lineal Ft.
6	95
8	169
10	264
12	368
14	517
16	676

force acts in a direct line between the two points of attachment. If the work is ring-shaped, it would tend to deform the ring.

A spreader of sufficient stiffness should be used between these two points to resist this collapsing force. It will be seen that eye-bolts are not suitable for attaching the slings to the work unless a spreader is used to relieve them of this side pull, which would put a heavy bending mo-

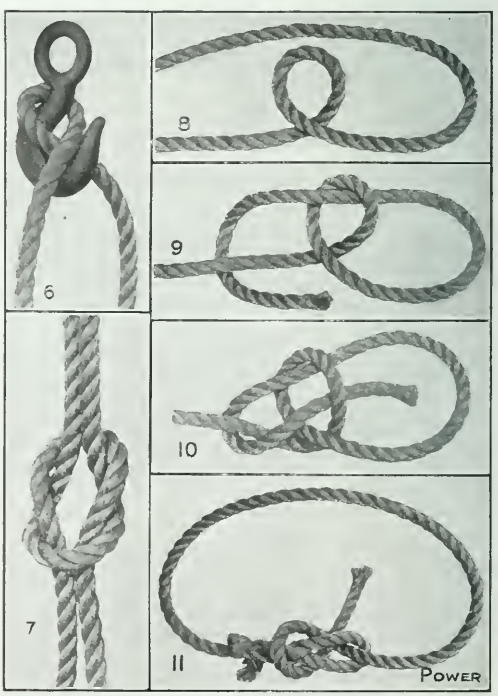


Fig. 6. Blackwall hitch, especially useful for hauling material on the level. Fig. 7. Square or reef knot used only for joining two ropes together. Figs. 8, 9 and 10. Steps in making a bowline knot. Fig. 11. Sheet bend in eye, generally used for an adjustable sling.

ment on the shank of the bolt. Reducing the angle between the sling and the work to 30 deg. makes the stress in each sling equal to the weight, and the collapsing force is also equal to the total weight. Such a small angle should never be used if avoidable.

Safe Loads on Ropes and Chains

When it is necessary to use eye-bolts for lifting loads, no greater stress should be allowed than given in Table 1, which shows the safe load in pounds for bolts up to and including 2¼ in. in diameter. It should be noted that the values given are correct only when the pull is in the direction of the arrow shown in Fig. 11, and when the bolt is in good condition.

Eye-bolts should never be painted when used for miscellaneous lifting, as paint is apt to cover up flaws. They should be tested occasionally by tapping gently with a hammer, but not sufficient to bend or to otherwise injure them. If they do not impart a good ring they may fit too loosely in the hole, or there may be a flaw.

Safe Load on Ropes and Chains

Table 3 gives the safe loads which may be put on manila rope, wire cables, and chains. The figures are in tons of 2000 lb. each. The loads for manila rope should be used only when the rope is in fairly good condition; when badly chafed or worn the load should be reduced.

As there are many kinds of material to handle, a short list of the weights of the various materials is given in Table 2. The weight of shafts are given per lineal foot.

A wood or lag screw, when made in the form of an eye-bolt, should never be used for hanging any hoisting tackle. Wherever possible the safest way to hang such tackle is by passing the shank of an eye-bolt through the floor or beam, properly protecting the wood by a large plate washer and nut. It frequently happens that a chain or rope sling can be used by passing it over a properly secured timber.

Fig. 14. Proportions of Eye-Bolts (See Table 1)

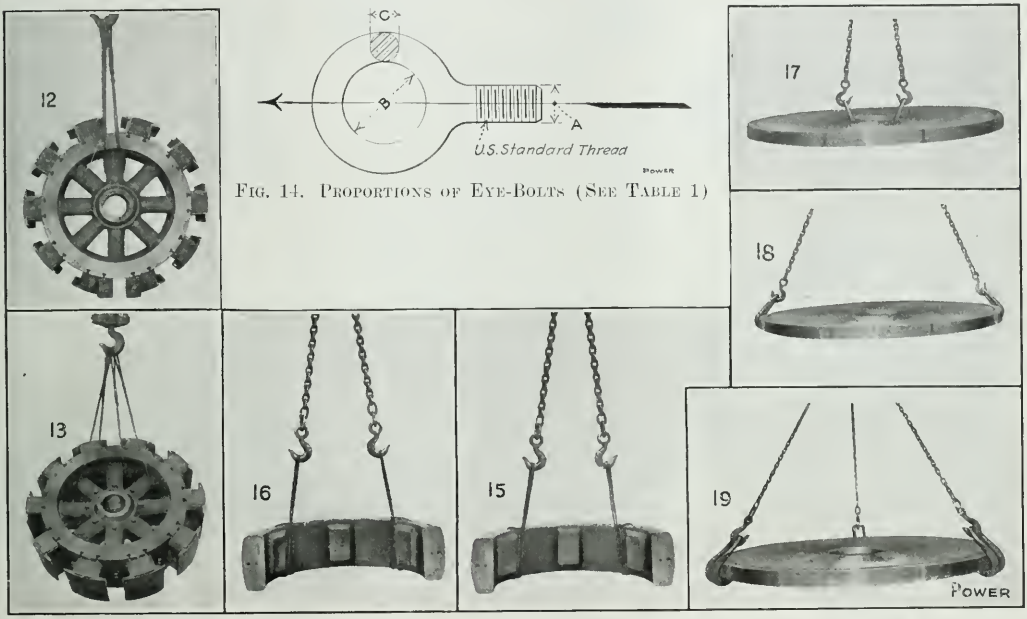


Fig. 12. Improper method of making a hitch for turning revolving fields with two slings. Fig. 13. Proper method of making hitch for turning revolving fields. Figs. 15 and 16. Wrong and right ways of making a hitch. Figs. 17 and 18. Wrong and right use of double hooks. Fig. 19. Three double hooks—preferable where possible.

TABLE 3 SAFE LOADS ON ROPES AND CHAINS

Manila Rope, Safe Load in Tons				Wire Cable, Safe Load in Tons		Chains, Safe Load in Tons			
Dia. of Rope, In.	Single Rope	Two Part	Four Part	Diam. of Cable, In.		Two Part	Four Part	Diam. of Chain, In.	Single Chain	Two Part	Four Part
¼	¼	½	¼	¼	1	2	3½	¼	½	¼	½
⅜	½	¾	½	⅜	1½	3½	6½	⅜	1	½	1
½	¾	1	¾	½	2½	¼	9	½	2	3½	6
⅝	1	1½	1	⅝	3½	6	12	⅝	3	5	9
¾	1½	2	1½	¾	4½	8	16	¾	5	9	15
1	2	3	2	1	6	12	24	⅞	6	10½	18
1¼	3	4	3	1¼	10	19	36	1	8	14	24
1½	4	6	4	1½	13	25	48	1¼	11	19	33
1¾	5	8	6	2	16	32	60	1½	13	23	39
2	6	10	8					1¾	18	32	54
2¼	7½	12	10								
2½	9	15	12								

Other defects besides those in lifting apparatus will occasionally be discovered, such as a cracked arm of a flywheel, or other similar piece. If this defect is discovered by the person originally handling the piece, he should call his superior's attention to it immediately upon making such discovery. Those engaged in this important work should also have some idea of the strength of materials. They should know how the strains will be set

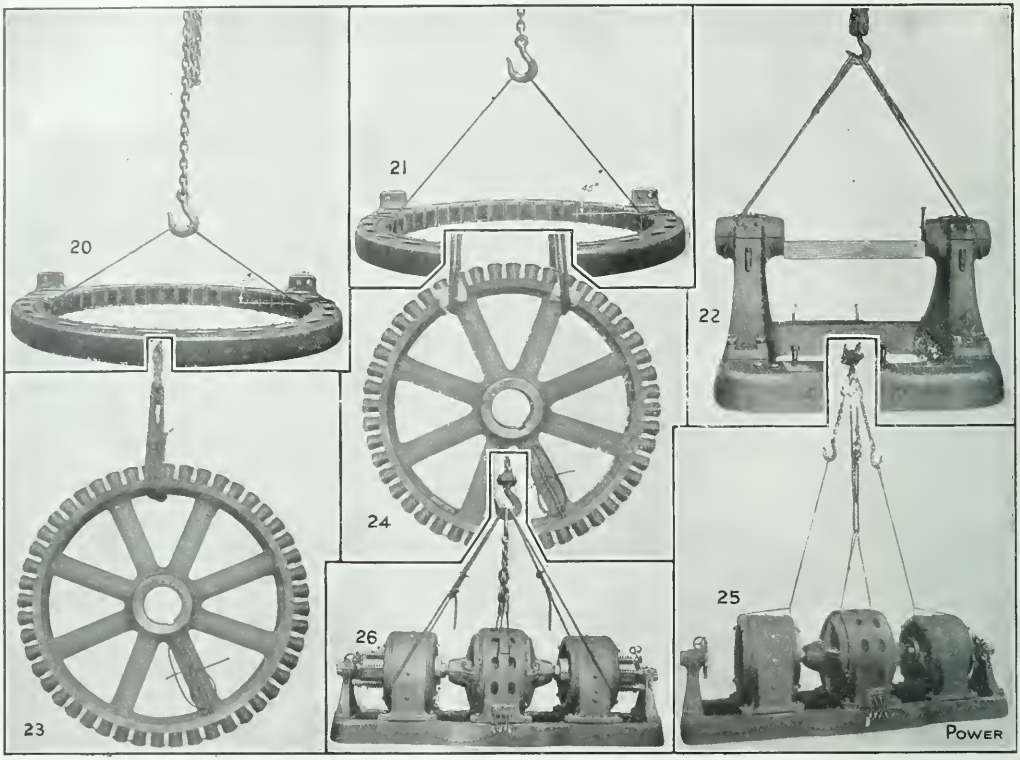


Fig. 20. 30-deg. angle sling (wrong way). Fig. 21. 45-deg. angle sling (right way). Fig. 22. Lifting a base with standards with provision for lateral strains. Fig. 23. Lifting revolving field (wrong way). Fig. 24. Lifting revolving field (right way). Figs. 25 and 26. Wrong and right ways of lifting motor-generator sets.

up in such materials, and also how to apply slings for lifting, as here illustrated. They should know that using too small an angle on the slings, as in the case of a field ring, would tend to pull the sides together; and that, in the case of a revolving field where the sling is applied between a pair of arms instead of around adjacent arms, the tendency would be to break out a portion of the ring. This is shown in Figs. 23 and 24.

⁂

A Word for the Reciprocating Engine

In discussing a paper read before the Hannover section of the Verein deutscher Ingenieure, by H. Klippe, upon the steam turbine, one of the participants took up the cudgel for the reciprocating engine.

The turbine works with a 90 per cent. vacuum; the engine with from 85 to 90. A 400-hp. reciprocating engine calls for 60 cu.m. of cooling water per hour for the condenser; the turbine needs 200 to get the extra 5 per cent. of vacuum. Hence, the turbine needs more space for the condensers, and it is not a fact that the turbine with its auxiliaries requires less space than a reciprocating engine of equal capacity.

The steam consumption of the reciprocating engine he maintained to be lower. In England a 1000-hp. Parsons turbine calls for 8.1 to 9.14 kg. (17.8 to 20.1 lb.) of steam per kilowatt-hour, and in Elberfeld Schröter reports for one of the same power 8.96 to 9.7 kg. (19.7 to 21.34 lb.). The same engines of the Hannover Electric Station at Herrenhausen are of about the same power but require only 7.5 to 8.2 kg. (16.5 to 18 lb.). Stodola rates the consumption of a steam turbine of 125 kw. at 11.57 kg. (25.45 lb.); one of 232 kw. at 9.93 kg. (21.84 lb.); of 497 kw. at 10.89 kg. (23.95 lb.), while the Hannoversche Maschinenbau A-G guarantees for engines of these capacities under the same conditions, 9.5, 9.2 and 9.1 kg. (20.9, 20.24 and 20.02 lb.). With the reciprocating steam engine, the work expended on the condenser is only 3 per cent.; with the turbine, 5 per cent.

⁂

Coal in South Africa

An estimate of the coal resources of the Union of South Africa, based upon geological surveys, yet only approximate, places the aggregate quantity at 55 billion tons. Most of the coal, about 36 billion tons, it would appear, is in the Transvaal, while in Natal the given quantity is 9400 million tons. The remainder, equal to say 9600 million tons, is distributed among the other provinces. The Union produced over 7½ million tons in 1911.—*Coal Age.*

⁂

Cases of pitting tubes in boilers are said to have been cured by connecting the inlet of the feed pipe to the blowoff pipe with a ½-in. copper bond.

ELECTRICAL DEPARTMENT

Alternator Testing

By F. S. Barton

All the losses in electrical machinery appear as heat and due to imperfect radiating properties, some of the heat is retained in the machine, which raises its temperature. The smaller a machine for the same amount of work the greater will be the proportionate losses and consequently the greater the heating. Competition forces manufacturers to build machines as close to the specified temperature rise as they can. The machine must do the work, yet be produced as reasonably as possible, which means that the amount of stock must be reduced till the temperature rise is a few degrees below that specified.

Temperature rise will be found to lie mainly between 35 and 45 deg. C. above the existing room temperature for runs at normal or rated full load. It is customary to specify a higher temperature for a run of two hours at 125 per cent. load. When specifying the allowable rise, one must not forget this is above room temperature, which in a generating room is variable. It is best to call for a comparatively small temperature rise, although it usually necessitates a somewhat more expensive machine.

It is now customary to measure temperatures of all parts of electrical machinery both by thermometers and by the rise-of-resistance method. The former method is inferior to the latter because the outer coils in contact with cooling mediums show a lower temperature than the interior windings. One should always specify that the temperature rise be determined by the rise-of-resistance method and checked by the thermometric method.

When laying out an alternating-current station it is necessary to know the amount of field current required to produce normal voltage at no load, full load and overloads for unity power factor and often for lower power factors. This will determine the size of field cables necessary, also the size of the exciters. A very useful curve to make for obtaining this information is known as a "saturation curve"; this has the general shape shown in Fig. 1 and is plotted between armature volts as ordinates and field amperes as abscissas, and is ordinarily taken with the armature open-circuited. This curve is so called because it shows the relation between the degree of magnetic saturation of the iron and the corresponding field excitation, the armature voltage being proportional to the magnetic flux at no load. As the voltage is also proportional to the speed it is essential that the speed be held constant throughout this test.

In conjunction with this curve a running impedance curve should be taken. This is plotted between armature amperes and field amperes, the alternator being short-circuited during the test. The curve takes the form of a straight line, as in Fig. 2, and the resulting armature currents lie considerably below the value to which they would rise momentarily if a short-circuit were thrown on the machine while running open-circuited with the same strength of field excitation. It is customary to hold the speed constant during this test, but it is not so necessary as in the case of the saturation curve, because alternating current is directly proportional to the voltage and inversely proportional to the impedance as expressed by

$$I = \frac{E}{\sqrt{R^2 + (2\pi f L)^2}}$$

Considering the expression for impedance, which is $\sqrt{R^2 + (2\pi f L)^2}$, it is remembered that the machine is short-circuited during this test and the resistance R is, therefore, practically negligible. Hence the impedance becomes $2\pi f L$ (or reactance only) and

$$I = \frac{E}{2\pi f L} = K\frac{E}{f}$$

In this expression, E (the voltage) is proportional to the speed as is also f (the frequency). The numerator and denominator both being proportional to the speed, any change of speed will not affect the value of the fraction, which is equal to I (the current). Actual experiment

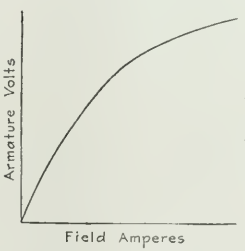


Fig. 1. Saturation Curve

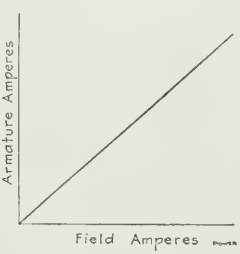


Fig. 2. Impedance Curve

bears out this interesting fact, for the current will hold up to normal till the machine is within a few revolutions of stopping.

Voltage Regulation

These two curves are useful in determining the voltage regulation on large alternators when it is impracticable to load them, actually. Generator regulation may be defined as the percentage change from normal voltage when full-load noninductive current is suddenly thrown off, holding the field excitation and speed the same. In most alternators this is about 6 or 8 per cent., but the smaller the regulation range, the larger and costlier the machine. Sometimes regulation is called for at 80 or 90 per cent. power factor; this is taken lagging, as a leading power factor would cause a drop in voltage if the load were thrown off. The present tendency, however, is not to lay so much stress on regulation, because of the admirable automatic regulation by the Tirrell regulator.

Efficiency

Efficiency is the ratio of the useful output to the total input, or letting

E = Total energy used in driving the generator;
E' = Energy available at terminals of the machine;
e = Total losses.

$$Efficiency = \frac{E'}{E} = \frac{E'}{E' + e} = \frac{E - e}{E}$$

The efficiency of ordinary alternators varies from 90 to 95 per cent. The losses consist of windage, bearing and brush friction, iron losses and copper losses. Methods of measuring and separating these will be discussed later.

Customers are more and more appreciating the fact that, while a short-circuit is not a normal condition, yet

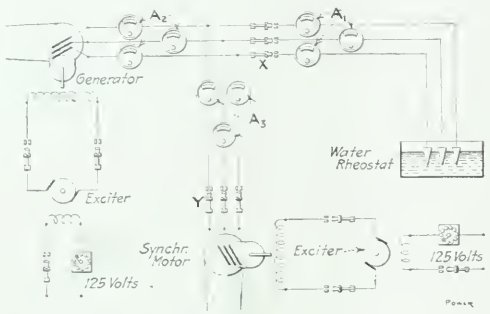


FIG. 3. TESTING ALTERNATOR BY MEANS OF SYNCHRONOUS MOTOR AND WATER RHEOSTAT

it may happen in any well ordered plant and the system to be operative must be able to withstand this.

HEAT RUN

Assume now that a representative is at the factory ready to inspect the alternator which is to be tested for his approval. He finds, if the size is small enough, that it is arranged to be driven at full load by some source of power whose speed can be held constant. While preparations are being made to commence the heat run, the inspector should look the machine over carefully for mechanical defects or undesirable construction. Meanwhile thermometers are being put on all important stationary parts; also several are hung nearby to get the room temperature. The machine should have stood at least 24 hr. so that it will have a consistent and uniform temperature in all its parts which should be at or near the room temperature. After carefully noting the field and armature temperatures by means of two or three thermometers, the resistances of both are measured and recorded. The heat test is now started at rated full-load current and normal voltage and speed. Records should be kept of armature volts, armature amperes, field volts and field amperes as well as the speed. Also the temperature of the field by "rise of resistance" should be calculated in connection with each set of readings, as follows:

Let

T_c = Temperature of field by thermometer when cold, degrees Centrigrade;
R_c = Corresponding resistance;
T_h = Temperature of field to be determined (hot), degrees Centigrade;
R_h = Corresponding resistance.

Then

$$\frac{T_h + 238}{T_c + 238} = \frac{R_h}{R_c}$$

To find the temperature of the field, it is necessary only to measure the current and voltage of the field, calculate the resistance and substitute in the foregoing equation. For instance, suppose that before starting the resistance was 0.9 ohm and the temperature of the field at that time was 30 deg. C. At some time during the run it is found that the field resistance has risen to one ohm. Then the temperature would be:

$$\frac{T_h + 238}{30 + 238} = \frac{1}{0.9}$$

whence,

$$T_h = \frac{30 + 238}{0.9} - 238 = 59.8^\circ\ C.$$

The test is continued till all parts show a constant temperature rise and no longer continue to increase. This usually requires from 4 to 6 hr. The machine is then shut down and thermometers are put on all moving parts quickly and the maximum temperatures are recorded. Meantime the field and armature resistances are being carefully measured, and from the hot and cold readings the temperatures are calculated and compared with the thermometer readings.

Perhaps the simplest and most usual way of securing a specified power factor for a power-factor heat run is by the use of a synchronous motor running at no load on the line and in parallel with the rheostat load. The field of this motor can be varied to secure any power factor desired.

Assume that a three-phase, 200-kw., 2300-volt alternator is to be tested at full load, 80 per cent. power factor. This would probably be connected to water rheostats for load and to a similar machine of the same frequency and voltage (in parallel with the rheostats) to be run as a synchronous motor to furnish the required power factor. Fig. 3 shows a diagram of the arrangement.

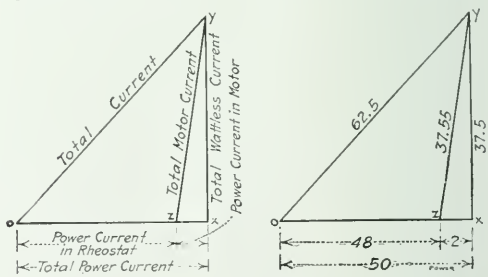


FIG. 4. CURRENT VALUES DETERMINED GRAPHICALLY

The normal generator current at unity power factor is:

$$I = \frac{W}{V \times \sqrt{3}} = \frac{200{,}000}{2300 \times 1.732} = 50.2$$

or 50 amp. (for convenience). This is the current that is necessary to develop 200 kw. at unity power factor at 2300 volts and is represented by ox in the current triangle in Fig. 4. But when running at 80 per cent. power factor, the armature current will be increased, due to the vectoral addition of wattless current; hence the total current will be $50 \div 0.8 = 62.5$, which is represented by oy. The wattless component of the current is xy, which equals

$$\sqrt{62.5^2 - 50^2} = \sqrt{3906.25 - 2500} = 37.5\ amp.$$

The test is now ready to be started, and a good way to bring the synchronous motor up to speed is outlined be-

low. Close the switches at Y (Fig. 3), leaving those at X open. Now put approximately normal field excitation on both machines and start the generator; this will bring up the motor in phase with the generator and avoid the necessity of synchronizing.

The first thing to do is to take a curve on the synchronous motor to determine its smallest input current. This is plotted between armature amperes and field amperes and has the general appearance shown in Fig. 5. Corresponding with no field on the motor is the large armature current at y. This gradually decreases as the field current is increased until it becomes a minimum at b, after which it will increase again with any further increase of field excitation. A number of points should be taken close together near b to determine the value of cb accurately. This is the minimum armature current necessary to run the synchronous motor and it is all power current; that is, current in phase with the voltage, and any addition to this is wattless. In other words, it is the current necessary at unity power factor to overcome the friction and other losses of the motor. Referring to Fig. 5, of the current ez, eh is power current and hz is the addition caused by the wattless current. All the wattless-current values to the left of *abc* (with an underexcited field) are lagging behind the voltage and those to the right, caused by an over-excited field, are leading.

Since eb is the power current necessary to run the motor light, this will constitute a part of the power current of the generator. On the triangle of currents, Fig. 4, lay off xz equal to this amount. Assume it to be 2 amp. This brings us to the point of calculating the total current that will be taken by the synchronous motor when producing an 80 per cent. power factor in the generator load. The total motor current would be xy if no power were necessary to overcome the friction, windage and other losses; but this is combined with the motor power current and produces the total motor current

$$yz = \sqrt{xz^2 + xy^2}$$

This figures 37.55, which is not much larger than the wattless current xy.

Manifestly, the current flowing in the water rheostats is $oz = ox - zx = 48$ amp. In other words, the 50 amp. total generator power current is composed of 2 amp., used to drive the motor and 48 amp. absorbed by water rheostats.

In making the heat run, at 80 per cent. power factor and full load, one man holds the synchronous-motor excitation at the value which was found to give the minimum motor current. The switches at X, Fig. 3, are now closed and the resistance in the water rheostats is cut down till the line current equals that corresponding to total power. The ammeters will then read 18 amp., at A_1, Fig. 3; 50 amp. at A_2 and 2 amp. at A_3. It should be noted that, at present, these currents are all at 100 per cent. power factor. One man should hold a current of 48 amp. on meters A_1 from now on till the end of the run, by adjusting the water rheostats when necessary. The synchronous-motor field is next weakened until the total current, read at A_2, is increased to 62.5 amp. The prescribed conditions, shown diagrammatically in Fig. 4, are now established and the meters at A_3 (Fig. 3) should read 37.55 amp. as a check.

If a regulation test is desired it should be done immediately after the heat run, while the machine is warm. This test has been described elsewhere and being simple it would be superfluous to describe it again here.

Very often it occurs that the machine is too large to be loaded fully on the testing floor. Under such conditions it is necessary to resort to compromise tests. These consist of an open-circuit and a short-circuit heat run.

Saturation and running impedance curves should be taken immediately previous to the open- and short-circuit runs respectively. The manufacturers specify some percentage above the normal voltage to be held constant for the open-circuit run and likewise some percentage excess over the normal current for the short-circuit run.

A better way to ascertain the excitation to hold during the open-circuit heat run is to determine the regulation by the use of the saturation and impedance curves. Suppose the excitation necessary to produce normal voltage at no load, according to the saturation curve, is i_1, and from the impedance curve the excitation to give normal armature current is i_2. Then the excitation current necessary to maintain normal voltage at full load is obtained by combining these two values at right angles:

$$I = \sqrt{(i_1)^2 + (i_2)^2}$$

This is the field current that should be held during the

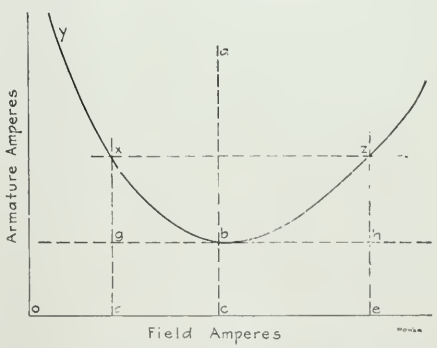


FIG. 5. SYNCHRONOUS MOTOR CHARACTERISTICS

open-circuit run, letting the voltage come what it will. Call this voltage V_1 and the normal voltage V. Then the calculated percentage regulation, R equals $\left(\frac{V_1 - V}{V}\right)$. Continuing such an open-circuit run until the temperatures are constant will give a very fair idea of the field temperatures that may be expected at full load.

Immediately following the open-circuit run, a short-circuit run should be started, at a considerable percentage above the rated current. This is a test on the armature, pure and simple, as the field excitation will be low.

EFFICIENCY FROM LOSSES

Should the purchaser wish to satisfy himself regarding the guarantees for efficiency, the procedure would be to measure the losses directly and compute the efficiency from them. The losses of an alternator may be classified as follows: Copper loss, iron loss, friction and windage. There are two subdivisions of copper loss, namely, field and armature loss. The field loss is determined by measuring the resistance of the field very carefully while hot. The loss in watts is then computed by substituting in the familiar expression, $W = I^2 R$. As to the armature loss,

the same expression can be used, as the reactance of the armature does not cause any heating.

The iron or core loss is composed of hysteresis and eddy-current losses. Its collective magnitude, including friction and windage, is determined by means of belting a small direct-current motor to the alternator and measuring the motor input in watts necessary to run the combination at various alternator excitations and later subtracting the power necessary to run the motor alone.

The belt used should be as light as possible and not laced but should be endless, because any irregularity will make the motor-input ammeter needle jump every time it passes over the pulley and thus increases the liability of error. Sometimes when all conditions are the best that can be obtained, the ammeter needle still has a very annoying swing. This has been overcome in several instances by reactance in the motor-armature circuit.

The motor field should be separately excited and the rheostats in the field circuit should be so arranged that some convenient field strength can be held constant throughout the test. This value of the field current must not be varied under any circumstances. The motor armature is to be wired to some independent source of power whose voltage can be varied at will over a considerable range. The rheostats for this purpose should be convenient to the man holding speed and the speed of the alternator must be held as close as possible to the normal value throughout the test, by varying the driving-motor voltage, the two brushes used to measure the armature voltage on the motor must be thoroughly insulated from their boxes by wrapping with paper. This will eliminate the drop due to brush and brush-holder resistances.

The motor and alternator should first be run at approximately normal speed for an hour or two until conditions become steady; then take readings for the core-loss curve. These are taken with the alternator open-circuited and are carried up to 25 per cent. above normal voltage. The field current for each point must be rising; that is, do not go above a certain value and then drop back to it again. If the field current rises above that intended, take the reading at the higher point. Take several readings close to normal excitation and one point exactly at normal. Readings may be conveniently tabulated according to the following form. After ten or twelve points have

Generator				Motor				
VA	VF	AF	Speed	VA	VF	AA	AF	Speed

been taken, plot a trial curve between motor-armature amperes and alternator excitation to see if any points are radically wrong and if they are, check them. There should be no sudden change in the motor voltages from one reading to the next. Now, without any excitation on the alternator, take a very careful reading on the motor. Next, remove the brushes from the alternator rings and take another reading if desired. This is to separate the brush friction, which may be so small that it cannot be read.

The belt is next removed and the power necessary to run the motor alone is determined. Hold the same field strength that was held throughout the core-loss curve; also hold normal speed by adjusting the voltage. After this the motor should be shut down and the armature carefully measured to determine the $I^2 R$ loss of the motor armature. Tabulate the alternator-field excitations and the corresponding motor-watts input, and plot the curve which has the general shape *ab*, Fig. 6. The motor watts at no alternator-field excitation are the friction, windage and brush losses of the alternator, including motor losses and are constant for all field strengths of the alternator except for the increment of additional $I^2 R$ loss over and above the runing light $I^2 R$ loss of the motor occasioned by increased armature current. These losses, excepting the variable additional $I^2 R$ loss of the motor, are represented by *cd*, *eg* representing the variable $I^2 R$ and *ef* the wattage input to the motor with the belt thrown off. Assume that the point *z* on the curve *ab* is at normal excitation. Then *wx* represents the "running light" motor losses, which are the same at every point; *xy* is the friction and windage of the alternator in watts, *yy'* is the additional $I^2 R$ loss of the motor, caused by the armature current in excess of that while running free and *y'z* is the core loss at that point. The proper core loss to use in calculating full-load efficiency, is that corresponding to the normal voltage plus the $I^2 R$ drop of the armature.

In addition to the core loss as determined, there is a second factor known as "load iron losses" and these are

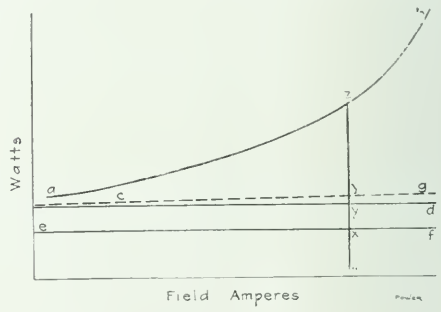


FIG. 6. VARIATION OF GENERATOR FIELD WITH MOTOR INPUT

not any too well understood. They are determined by taking readings for a core-loss curve as outlined, but with the armature short-circuited. This value, for full-load conditions, equals the core loss thus determined (with rated full-load current flowing in the armature), minus the $I^2 R$ of the armature, the remainder being divided by 3; that is $(W - I^2R) \div 3$.

Representing the total losses of full load by L, the efficiency is $E = W \div (W - L)$ where W is the watts output.

This completes the running tests usually called for on alternating-current generators.

INSULATION TEST

There remains the high potential test on the insulation. This should be made while the insulation is warm, because in this condition its dielectric strength is likely to be somewhat less than when cold. In every case the voltage is applied between the windings and the iron, and is left on for a period of one minute. For high-voltage machines the amount of test potential put on the armature windings is usually about double the normal terminal voltage, but on the lower voltage machines this amount is usually increased. Revolving fields all take 2300 volts or thereabouts, applied between the windings and the core.

GAS POWER DEPARTMENT

Gas Power Plant in Wool Warehouses

By E. F. Learned

The gas power plant herein described serves two wool warehouses located at South Boston, one of which is the largest in the United States. The buildings are of brick and concrete, the larger 478 ft. long, 122 ft. wide and nine stories in height. In the rear and at one end of

Warehouses in Which Plant is Installed

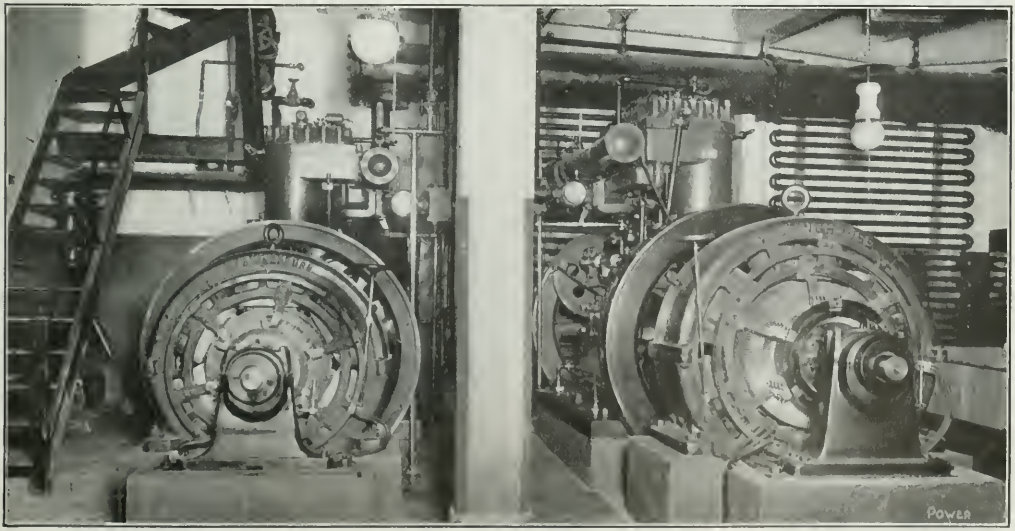
the structure, but separated from it by a narrow street, is another building about 138x107 ft., and of the same height. The total floor area of the two buildings is about 16½ acres, and the storage capacity is 10,000,000 lb. of wool. The power plant is underneath the street between the buildings and supplies electricity for the lighting and the power load.

The buildings are equipped with six passenger elevators of 1500 lb. capacity running at a speed of 100 ft. per min., nine freight elevators of 5000 lb. capacity operating at 100 ft. per min. and nine whip hoists lifting a maximum load of 400 lb. at 500 ft. per min. These machines are electrically driven.

There are two main units consisting of Nash gas engines, direct connected to Westinghouse 230-volt, direct-current generators running at 250 r.p.m. One is a 150-hp., 13x16-in., three-cylinder engine driving a 90-kw. dynamo, and the other a 100-hp., 11x14-in. three-cylinder engine driving a 62½-kw. machine. The generators deliver current to a three-wire system, all the motors being supplied from the 230-volt circuits. A rotary balancer is installed on the lighting system.

The fuel is illuminating gas, supplied by the Boston Consolidated Gas Co., a 5-in. line being carried from the service connection to two 500-light meters, with connections so arranged that the gas can flow either through both meters or one can be used as a spare. The engines are supplied through 4- and 3-in. branches from a 6-in. line leading from the meters. A bypassed regulator is provided in each branch.

Six vertical air tanks, working under 180 lb. pressure and supplied by a 6x6-in. motor-driven Curtis compressor, are provided for starting the engines. Cooling water for the compressor is supplied through a ½-in. pipe from the city service. The tanks discharge into a 1¼-in. line serving each engine. An auxiliary com-

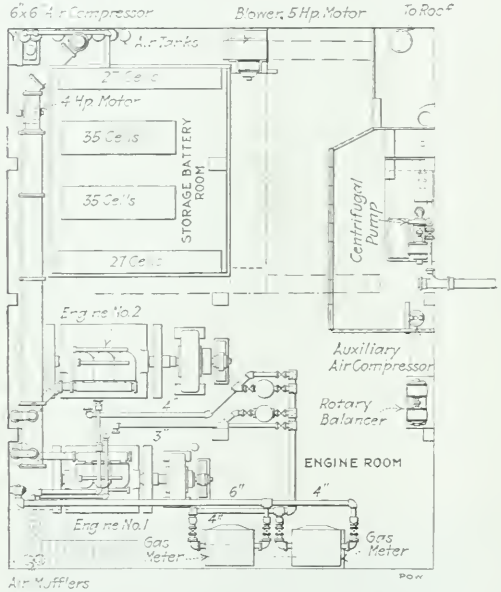


General View of Engine Room

pressor, belt driven by an 18-in. Pelton wheel, is installed with a 1-in. pipe connecting to the $1\frac{1}{4}$-in. air line. This wheel is supplied under about 48 lb. pressure by a $2\frac{1}{2}$-in. pipe from the service connection and discharges into the sewer.

The exhaust pipes from the engines are 6 and 5 in., respectively, and lead to mufflers discharging into an 18-in. manifold about $26\frac{1}{2}$ ft. long. A 12-in. pipe connects the manifold with a 12-in. wrought-iron riser extending 6 ft. above the roof. The pipe and riser are drained by a 1-in. pipe leading to a $2\frac{1}{2}$-in. drip line from the mufflers.

Cooling water for the engines is supplied through $1\frac{1}{2}$- and $1\frac{1}{4}$-in. branches from the city water supply. The heated jacket water may be used in heating the plant by passing it through two 2-in. return-bend wall coils, each containing about 350 sq.ft. of radiating surface, or it may flow through connections to a $2\frac{1}{2}$-in. line and siphon into the sewer. The siphon is fitted with a check valve and an overflow pipe leading to a sink. Low-pressure boilers are also installed, however, for heating the offices.



Plan of Engine and Battery Rooms

Provision for engine ignition is made by 20 cells of type "ET" chloride accumulators and a 2-hp. motor-generator set. The capacity of the storage battery is 20 amp.-hr. at 40 volts. Current from the battery is used in starting the engines, and after the generators are in operation the motor-generator is switched into service, either supplying the batteries or furnishing the ignition current.

A third system of electric ignition is provided by the use of an independent source of electricity consisting of 24 cells of dry battery with leads carried in a separate conduit to the engines.

There are also 124 cells of type "E 11" chloride accumulators having a rated capacity of 25 amp. for 8 hr. During the day the battery is used to regulate load fluctuations through a range of about 125 amp. At night it supplies the lighting and elevator service after the generators are shut down. The battery jars are of such size that the rating of the battery can be increased 50 per cent. by the installation of additional plates.

The main circuit-breakers are equipped with reverse-current relays to insure against trouble caused by an engine working badly when the generators are connected in parallel, or from the battery feeding back to the machines.

The power load consists of six 10-hp. motors, nine 20-hp. motors, and nine 11.5-hp. motors operating respectively the passenger and freight elevators, and the whips. The lighting load consists of 2805 sixteen-candlepower equivalents. Only one generator is operated at a time, the other being held in reserve.

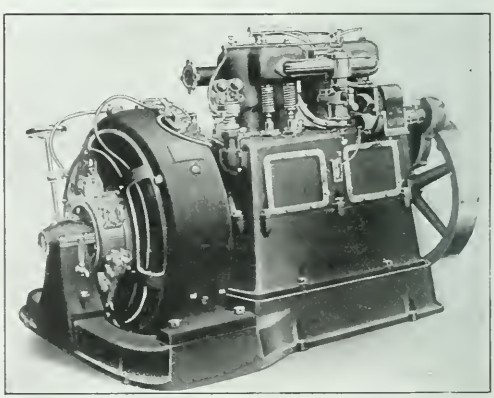
The plant is ventilated by natural and forced-draft systems. Two brick vent stacks about 5x5 ft. in section are located at opposite corners on the same side of the engine room, extending from the ceiling to a height of approximately 10 ft. above the level of the street. Swinging sashes are provided at the tops of the stacks permitting the draft to be regulated at will. In the forced system of ventilation the air is withdrawn from the upper portion of the engine and battery rooms through ducts and is exhausted by a 50-in. motor-driven blower which exhausts into a duct leading to a 20-in. galvanized-iron duct carried to the roof. There are openings about one foot square near the floor in each side of the battery room permitting a circulation of air to be maintained.

The engine room is lighted by gas, arc and incandescent lamps.

The installation was designed by W. H. Edmondson, engineer of the Boston Consolidated Gas Co.

Gasoline-Electric Generating Set

A line of small gasoline-electric generating sets, intended primarily for such service as country estates, shops, vessels, etc., has recently been put out by the B. F. Sturtevant Co., of Hyde Park, Mass. At present three sizes are built, namely, 5, 10 and 15 kw., the engine being mounted on the same base as the direct-current generator.



10-Kw. Gasoline-Electric Generating Set

The engines are of the four-stroke-cycle, vertical, multi-

cylinder, long-stroke type with four or six cylinders, according to the capacity. In the 5-kw. set the cylinders are cast "en bloc" with inclos J valves and integral inlet and exhaust manifolds; in the larger sizes the cylinders are cast in pairs as in the illustration.

Forced lubrication is employed, oil being supplied under 20 lb. pressure to all the bearings by a gear-driven pump. The lower part of the base forms an oil reservoir holding sufficient oil for 50 hrs.' use.

Regulation is effected through a centrifugal governor, driven by bevel gears from the camshaft and controlling a throttle valve.

To Investigate Substitutes for Gasoline

Announcement is made of the active coöperation of the National Association of Automobile Manufacturers and the Society of Automobile Engineers in a movement to investigate the applicability of kerosene and other low-grade petroleum products as a substitute for gasoline. This movement is significant in that it is the first definite response to the present complaints throughout the country against the advance in price of gasoline accompanied by a lower-grade product.

Although only tentative plans have been made thus far, the commercial side of the problem will be handled by the manufacturers' association and the research work will be looked after by the automobile engineers.

Special opportunity will be given inventors and others who are interested in the development of new fuels as substitutes for gasoline to demonstrate not only their applicability to automobile propulsion, but also the extent to which they can be produced and the probable relative cost. In this connection the investigation will study fuels, such as the new motor spirits, recently placed on the market by the Standard Oil Co., of Indiana, which is manufactured from a residue formerly marketed at a low price as fuel oil.

Coal tar, peat and even vegetable refuse are possible sources of hydrocarbon compounds that may be used as fuel that are at present under investigation by various authorities, while several companies have recently undertaken the exploitation of fuels declared to be suitable as gasoline substitutes which are not directly dependent on the petroleum market, or which are entirely independent of it. Those interested in substitute products, as well as in new processes for increasing the yield of gasoline and similar products from petroleum itself will be invited to place them before the investigators.

In a similar way, inventors of carburetors and other devices calculated to adapt the ordinary gasoline engine to the use of kerosene, distillate and similar low-grade fuels, will be given opportunity to demonstrate their merits to the satisfaction of the investigators. An important aspect of the work will be a study of the carburetion methods at present employed with a view to determining what modifications are necessary in order to cope with the low-grade gasoline that is available at present, and pending possible relief, from whatever source it may be derived.

Considering the convenience that it affords and the price of retail current from central stations, electricity from a gasoline-electric plant can be produced at a cost that will stand very favorable comparison with the cost of a similar supply from any other source.—"The Isolated Plant."

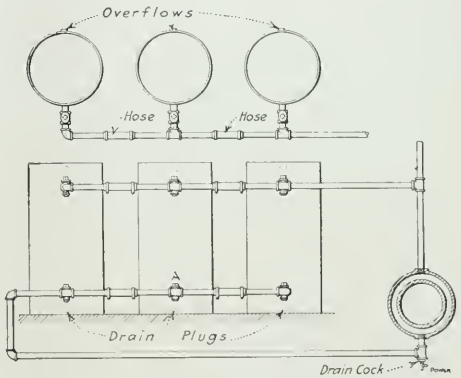
CORRESPONDENCE

Circulating Systems

In an article on "Gas Engine Jacket Circulating Systems," by A. C. Wilson, in the Mar. 4 issue, methods are given for connecting circulating tanks. There are several objections, however, to the use of tanks connected, according to the methods shown.

One very serious objection is that it would be impossible to cut out one tank in case of a leak, or other necessity, without cutting off the water from the engine altogether. Also in Figs. 3 and 4, the hot water coming from the engine jacket must descend to the bottom of the first tank, then rise to the top and enter the second tank, then descend to the bottom and so on. In my opinion this would result in poor circulation.

The sketch herewith submitted shows the method used by one of the largest builders of gas engines in the United



Suggested Arrangement of Tanks

States. By this arrangement any tank in the series may be cut out without affecting the circulation of the water through the remaining tanks. This is very convenient, for, in case a tank should spring a leak, it can be shut off from the line, drained and repaired. Also, in cold weather when it is not always necessary to use all the tanks one or more may be cut out to keep the water at the proper temperature. This is very important on hoisting engines where the load is intermittent and the engine operates a part of the time without a load.

In engines above 32 hp., a circulating pump is placed in the lower pipe line.

C. C. Dwight.

Salt Lake City, Utah.

If you work for a man, in Heaven's name work for him. If he pays you wages that supply your bread and butter, work for him; speak well of him; stand by him and stand by the institution he represents. If put to a pinch, an ounce of loyalty is worth a pound of cleverness. If you must vilify, condemn and eternally disparage, why, resign your position and, if you are a weakling, when you are outside damn to your heart's content. But as long as you are a part of the institution, do not condemn it.—"Pacific Service Magazine."

REFRIGERATION DEPARTMENT

Refrigeration with Carbon Dioxide

In previous articles in this department the use of ammonia for refrigeration by means of the compression and absorption systems was described. There are other mediums which have been used with varying degrees of success. Air, sulphuric ether, sulphur dioxide and carbon dioxide may be mentioned as examples, and of these carbon dioxide now has much wider use than any of the others. It is commonly called carbonic-acid gas and its chemical symbol is CO_2, which means one part of carbon to two parts of oxygen by volume. As a gas it is present in the air in volumes varying from 2.7 to 3.5 in 1000. It is the substance used in soda fountains and causes the effervescence in wines and beers. Commercially it is produced from coke, magnesite and other substances, or may be collected from the fermenting tubs in breweries. With the proper apparatus it may be obtained from the air or even from the flue gases of a boiler. It is comparatively cheap and due to its neutral action toward materials and food products it is largely used for the refrigeration of storage rooms in hotels and restaurants. It is also preferred at sea, as leakage of ammonia vapor into the limited volume of a vessel might readily produce disagreeable and perhaps fatal results. Air containing up to 8 per cent. of carbonic-acid gas may be inhaled without danger, whereas ½ per cent. of ammonia may prove fatal. The gas is without color and odorless, and the presence of a leak may not be easily detected, unless peppermint or some other substance with a strong odor is injected in the refrigerating system. It is heavier than air, its specific gravity being 1.529, so that it will tend to drop to the floor of the engine room and may not reach the breathing line.

Under atmospheric pressure carbon dioxide will boil at a temperature of 124 deg. F. below zero. At a temperature of 96 deg. it requires a pressure of nearly 1100 lb. to liquify it, at 30 deg. a pressure of approximately 500 lb. and at zero a pressure close to 300 lb. Its latent heat at zero temperature is 123 B.t.u. as compared to 570 for ammonia. In other words, one pound of the liquid at the given temperature, in changing into a gas in the expansion coils, will take up only 123 heat units from the surrounding room or brine. For the same volume, however, at a temperature of zero, carbon dioxide is about 32 times heavier than ammonia, so that a compressor to give the same refrigerating effect need be only one-seventh as large. In ordinary practice the ratio is usually placed at 1 to 6. The working pressure ranges from 50 to 70 atmospheres (750 to 1050 lb.), but the bore in machines of moderate capacity is so small that there is no difficulty in obtaining a cylinder and fittings to withstand the pressure.

As the operation is identical with that of the ammonia-compression system there will be no need of an illustration. Reference may be made to the previous drawing, which shows a compressor, condenser, expansion valve and expansion coils. These are the essential parts of a compression system using carbon dioxide. The drawing indicates an atmospheric condenser and shows the expansion coils located in a brine tank. In modernly equipped plants double-pipe counter-current condensers are usually installed and also double-pipe brine coolers. The direct-expansion system, in which the coils are located directly in the room to be cooled, may be used with equal facility unless the storage of a cold supply of brine to carry the plant over periods of nonoperation is desired.

For average operating conditions carbon dioxide gives results almost as efficient as ammonia. As the temperature of the cooling water increases, its efficiency falls off rapidly, and with water near 90 deg. is considerably lower than for ammonia with the same temperature of water.

Winter Work in a Refrigerating Plant

By Fred Ophüls

In the Mar. 25 issue of Power, an article* appeared under the same heading in which some of the various causes which give rise to the decrease in the ice output of a simple can ice-making plant are given. It is interesting to give some actual figures which can be obtained from the engineer's log therein referred to.

Ammonia Compressor

A great deal has been said about the proper way to operate an ammonia compressor to develop its greatest pumping capacity. The engineer had heard that some of the ice-machine manufacturers advocated operating their ammonia compressors with wet ammonia vapor. The quality of the vapor entering the compressor can be approximately determined by the discharge temperature. That is to say, when the compressor is operating with a 15-lb. suction pressure and a 185-lb. condenser pressure, saturated vapor, carrying no liquor with it, would leave a compressor, with some little clearance, at a temperature of about 250 deg. F. If moisture is present the discharge temperature is decreased and can be decreased until the boiling point of the liquid ammonia at the discharge pressure is nearly reached. The wet-gas compressors are generally operated with a discharge temperature of from 150 to 180 deg. F., for the range of pressures above given.

The engineer thought it wise to investigate this claim for himself and operated his ice-making system for a week so that the discharge temperature was maintained at between 150 and 180 deg. F. To his great astonishment he found that there was a marked reduction in the output of the plant when the machine was operating at the speed which he had previously found to give the best

*In this article an error crept into a sentence at about the middle of the third paragraph of the first column on page 422. The sentence should read: "While it has been often suggested to collect these gases in a separate receiver located over the condenser and connected with it, this method is not as effective as blowing off each condenser stand separately when practically all the ammonia has been pumped back into the condenser and receiver." The four words, "the other stands of," should have been omitted as they imply a different method of procedure.

results. The ice output showed a decrease of fully 20 per cent. This enormous decrease was found to have been caused solely by a decrease in the pumping capacity of the ammonia compressor due to carrying over or injecting liquid ammonia into the compressor.

A well designed ammonia compressor in good condition will draw from the suction pipe 75 cu.ft. of saturated ammonia vapor for every 100 cu.ft. of piston displacement. The injection of liquid ammonia into the compressor had reduced the amount of ammonia vapor pumped from 75 to 60 cu.ft. per 100 cu.ft. of piston displacement.

While theoretically it can be proved that the presence of liquid ammonia in an atomized form throughout the vapor during the suction period should result in an increase of the pumping capacity, results of actual tests have shown that this condition of operation cannot be reproduced and that liquid ammonia if carried over from the ice-making side of the plant or injected at the compressor enters the latter in bulk and lodges against the internal heated surfaces of the compressor, causing an undue reëxpansion on the return stroke of the piston on account of the rapid transmission of heat to the liquid from the metal surfaces.

For compressors with small clearance it is sometimes necessary to carry the discharge temperature as high as from 275 to 290 deg. F. for the pressure range above given. The operating engineer can readily determine at what discharge temperature his ammonia compressor will operate most efficiently if he takes the necessary trouble to maintain conditions nearly constant for a week and by varying the discharge temperature each week at least 25 deg. F.

It is difficult to give in figures the reduction in pumping capacity of an ammonia compressor on account of the leakage of the valves, valve-cage joints and pistons. For very large leakage, such as may be caused by the sticking of valves, the pumping capacity can be reduced to nothing and the only way to control this cause of loss in output is to make the provisions at the compressor suggested in the former article.

Lubricating Oil

The importance of having proper lubricating oil for the ammonia compressor is often overlooked. Very few oils are really suitable for this part of the machinery and often, on account of cheapness of price, an oil is bought which will cost the purchaser in loss of capacity, many hundred times as much as he saved on the oil. If it is taken into consideration that for a discharge temperature of, say, 250 deg. F., and a volumetric efficiency of 75 per cent. the actual temperature of the vapor at the end of compression may be as high as 380 deg. F., it will be appreciated that the quality of the oil plays an important part in the operation of the compressor.

The suction gas entering the compressor can have a temperature as low as zero for a suction pressure of 15 lb. gage, so that it is desirable to use an oil which has a congealing point below zero and a flash point higher than 380 deg. F. Such an oil is difficult if not impossible to obtain and if any compromise has to be made in these qualities it will be better to sacrifice the congealing point rather than the flash point where the oil is used for lubricating the compressor only.

When a low flash point oil is used, the action of the heat of compression on the thin film of oil covering the internal compressor surfaces will cause some of the oil to vaporize. Part of the vaporized oil is discharged into the condenser, another part remains in the clearance of the compressor. The percentage of oil vapor in the clearance at the end of the compression stroke is probably greater than is generally believed and as soon as the piston starts on the return stroke this vapor will give up its latent heat again in condensing and, therefore, maintain a high temperature until the suction valves open. In this way the percentage of reëxpansion is increased and the amount of vapor that can be drawn into the compressor decreased. That some of the lubricating oil actually vaporizes in most ammonia-compression systems is beyond doubt, as anyone knows who has had occasion to operate and study this type of machinery.

In air-compressor practice proper lubrication has been found to be a serious question, as lubricating oils of too low a flash point have often been the cause of explosions, an explosive mixture being formed by the oil vapor and the air. For this reason it has also been found dangerous to compress air with ammonia compressors that have been in service for some time. In these machines all the internal surfaces of the compressor and its piping are coated with a thin layer of a low flash-point oil. When air is compressed from atmospheric pressure to about 200 lb. gage for testing ammonia coils a temperature is reached in and near the compressor which is higher than the flash point of the oil and explosions have resulted from this cause. Ammonia compressors should never be used for compressing air unless they and their pipe connections have been thoroughly cleaned and coated with fresh oil of a sufficiently high flash point.

Ammonia Condenser

The amount of steam required to operate a refrigerating system not only varies with the suction pressure but also with the condenser pressure. The higher the former and the lower the latter the less steam will be required. In such plants where there is more than sufficient cooling and condensing water available the question comes up as to what quantity of water showered over the ammonia condensers will give the least total steam consumption of the refrigerating machine and the water pump. The minimum point can be found both by experiment and calculation. In the former case it is only necessary to operate the plant with varying quantities of water showered over the ammonia condenser and by plotting the results so obtained the minimum steam consumption can be determined. The calculation of this problem requires a knowledge of the horsepower necessary to operate the refrigerating machine under varying suction and condensing pressures, the steam consumption of its engine per horsepower-hour, the variation in the condenser pressure and liquid ammonia temperatures with the quantity of water used, the initial temperature of the condensing water, the total head against which the water must be pumped, the steam consumption of the water pump, and its mechanical and volumetric efficiencies. On account of the great variation in the initial temperature of the condensing water, the initial steam pressure and the type of the engine operating the refrigerating machine, these calculations must be made for each individual installation.

For the plant from which these data were taken it was

found that with 70 deg. F. water showered over the ammonia condenser using a duplex, direct-acting steam pump working against a total head of 150 ft., the minimum combined steam consumption of the refrigerating machine and water pump was obtained when 1.7 gal. of water per minute were showered over the ammonia condenser per actual ton of refrigeration produced. The refrigerating machine was operated by a Corliss steam engine using about 28 lb. of steam per indicated horsepower-hour.

The log data also showed that the temperature of the liquid ammonia leaving the condenser was from 10 to 15 deg. higher than the initial temperature of the condensing water used. By installing a separate liquid cooler this difference was reduced to 5 deg. with a corresponding saving in the steam consumption of the refrigerating machine of about 2½ per cent.

Distilled Water

There are a great many ice-making plants in operation today in which the distilled water enters the ice-making cans at 70 deg. F. and higher. If one remembers that this water must first be cooled to 32 deg. F. before it will freeze and that due to its construction a simple can ice-making system does not remove heat efficiently, it will be appreciated that not only an increase in capacity but also a decrease in the operating expenses can be secured by reducing the temperature of the distilled water to about 32 deg. F. before it enters the ice cans. For example, it was found that by reducing the distilled water from 70 to 35 deg. F. in a separate distilled water cooler of proper construction, the capacity of the freezing tanks was increased 15 per cent. This does not mean that with the same ammonia compressor 15 per cent. more ice could be made, but that if an additional compressor is installed or else the existing compressor could be speeded up sufficiently the freezing tank would give 15 per cent. more ice without an expenditure of one cent in its equipment.

Freezing Tank

About 48 hr. are required to freeze a 300-lb. block of ice of standard dimensions. In the plant under consideration it was found that in certain parts of the tank the cans froze more rapidly than in others. On closer investigation it was determined to improve the circulation of the brine and also raise its level in the tank about 1 in. The result was a gain of 2 hr. in the time of freezing, which meant an increase in the ice output of the tank of 5 per cent., and a decrease in the total cost of manufacturing the ice of about 5c. per ton solely on account of the increase in capacity for the same initial investment. This meant for a 100-ton ice-making plant making 24,000 tons of ice per year, a saving of $1200.

The effect of the improper handling of the expansion valves is difficult to express in terms of per cent. of output as this cause of loss in capacity varies enormously. It has been proved that by installing the flooded or gravity-feed system the capacity of the plant in some cases can be increased 10 per cent.; everything else, such as the speed of the machine, condenser-water pump, etc., remaining the same. This figure also represents the saving that could have been effected by a proper manipulation of the expansion valves of the simple system provided the brine-cooling coils had been properly proportioned for the work.

Compressor Diagrams

It is very seldom that I see any indicator diagrams from ammonia compressors in Power. Having had occasion to take some diagrams, I thought that they might interest other engineers.

Figs. 1 and 2 were taken from a Ball compressor equipped with the old-style suction and discharge valves, which are not as efficient as the newer style of valves placed in the heads of the compressor. This machine has a refrigerating capacity of 125 tons, and is driven by a tandem-compound Corliss engine cross-connected. The compressor diagrams were taken at different suction and discharge pressures and at different speeds, 58 and 48 r.p.m. The cylinder was 21x48 in., and the piston rod 1¼ in. in diameter. Following is the data relating to the diagrams:

	Card No. 1	Card No. 2
Head pressure, lb	155	135
Suction pressure, lb	18	25
R.p.m.	58	48
Spring	120	120

Figs. 3 and 4 were taken from the high- and low-pressure cylinders of the engine. The operating data are tabulated below.

Fig. 1. Compressor Diagrams, Speed 58 R.P.M.

Fig. 2. Compressor Diagrams, Speed 48 R.P.M.

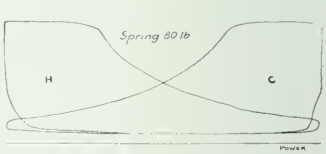


Fig. 3. Diagrams from High-Pressure Cylinder of Engine

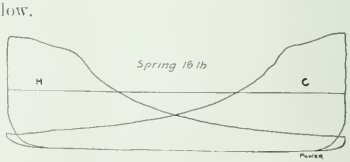


Fig. 4. Low-Pressure Cylinder Diagrams

Steam pressure, lb.	125
Receiver pressure, lb.	11
Vacuum, in.	24
R.p.m.	58 and 48
Diameter low-pressure cylinder, in.	38
Diameter high-pressure cylinder, in.	18
Diameter of rod, in.	1¼
Stroke, in	48

C. E. Anderson.

Chicago, Ill.

EDITORIALS

The Coming Engineer

Do you realize what 15,000 kilowatts mean?

With an overall efficiency of ninety per cent. it means nearly 23,000 indicated horsepower.

On a recent visit to the Westinghouse shops at East Pittsburgh, we found seventeen units of this capacity under order. There were also units of 20,000 and 22,500 kilowatts and numerous smaller units in the shop.

What does this mean?

It means that there are upward of 500,000 indicated horsepower of reciprocating engines which are not going to be built nor run.

It means that there is the equivalent of upward of 500,000 indicated horsepower of old-fashioned stationary engineers who are not going to be required to run them.

There are going to be fewer engineers, but they are going to be bigger, better engineers. The little slip-shod plant and the engineer who is not much more than a janitor is going to be displaced by these big efficient units in central stations. The man who will hold his job will be the man who can run his plant cheaper than the central station can sell the service, and who is able to show his employer that he can do so, against the most aggressive and efficient selling organization that this age of progress has produced.

Don't be old-fashioned; don't be stationary. Qualify yourselves to take care of one of these big stations or at least to so run a smaller one that the big one cannot wipe it out.

⁂

The Manufacturers' Opportunity

Professors preponderate as authors of papers presented before engineering and similar societies and comparatively few are contributed by heads of manufacturing firms. Attention was called to these facts by Prof. A. K. Huntington in his presidential address to the Institute of Metals.

Due to their special experience, often gained by hard toil and years of experiment, manufacturers should be able to give out a wealth of valuable information, and yet from a membership of manufacturers, users and scientific men in the relative proportions of thirty-seven, thirty-four and twenty-nine per cent., the percentage of papers presented was nine, fifteen and seventy-five. In the technical press, the same proportions would not hold, but the user and scientific man have a long lead over the manufacturer.

One has not far to go to discover the reason for this disparity. As a rule, the manufacturer has little inclination to write. His time is fully occupied, and even if he had the time and disposition, he is adverse to giving away so called trade secrets, more particularly if the information is such that the patent office offers no protection. These at least are the doctrines of the old school. The uptodate manufacturer is beginning to realize that there is nothing gained by secrecy. What he has learned as a specialist and what he is doing are of interest to the other fellow and the information from others in the same line is of value to him. The publication of this material with the ensuing discussion would add materially to the general store of knowledge.

Hiding one's light under a bushel never resulted in any lasting benefit to those concerned. It is a narrow policy which, if observed by all, hinders development and curtails business possibilities. To be recognized as the leading authority in the country on a particular subject is worth something to the manufacturer, and to turn over to the user his information on the subject is worth more. A mysterious machine or device, whose operation and construction are not thoroughly understood, is not the machine that will sell and continue to be a steady source of income to the firm. It is the machine that everybody knows, the machine that any user can operate and one whose efficiency lives up to its reputation, which will be in constant demand.

A thorough knowledge on the part of the user bespeaks confidence and the individual imparting this information in a form understandable to the average reader, incidentally helps himself. He classifies his own ideas, crystallizes them into more definite form and has them available at his "finger tips." The many little sidelights that he will invariably put into his work are the "fine adjustments," which bring his product to a focus and dispel the haze surrounding an unknown device.

A realization of these facts on the part of the manufacturer should result in some real information, and the more the better.

⁂

Unsymmetrical Boiler Joints

A paper read before the New South Wales Engineering Association, an abstract of which was given in a recent issue, apparently indicates that the exact shape of the joined ends of the plate has a marked effect on the maximum fiber stresses that may be produced along the joined surfaces; and especially at the point where lap cracks tend to form.

It is well known that relatively few of the total number of lap joints used in boilers actually produce explosions by cracking. It is not possible to know how many seams of this form of construction have started a crack or been on the verge of explosion at the time the boilers, on which they were located, were abandoned. However, it is safe to assume that if all were carefully examined, a large majority would be found perfectly sound. With tests of only two specimens, as given in the paper referred to, ample evidence was given of the widely varying stresses that may be expected in this form of construction by changing the form of the joined ends of the plate. Several years ago, POWER contained the explanation of a theory regarding the formation of cracks in the vicinity of boiler seams. This theory assumed that at some more or less well defined pressure the initial spring in the plate (caused by the forcible connection by rivet-

ing of mismated ends of the plate) was just overcome.

It was also assumed that when the working pressure happened to coincide with this initial pressure, a movement of the joint might be caused by very small fluctuations in the pressure: say, such as might be produced by the intermittent draft of steam to supply a reciprocating engine. If this theory is correct, it would seem to supply all the required flexibility to account for the erratic nature of the formation exhibited by the cracks in most forms of boiler joints. It would be interesting to ascertain by using fixed mirrors, as described in the paper referred to, if joints formed with mismatched plates do show a point of marked minimum resistance to deformation when the vessel, of which they form a part, is subjected to internal pressure. If so, the frequent application and release of the high surface tension which would be produced in such joints and which would likely be confined to narrow limits, would eliminate quality of material as a necessary factor in the formation of such cracks.

It is interesting that, although the claim has often been made that defective material is the true explanation of such failures, there has been practically no direct evidence that this is a fact. In two cases mentioned in the paper to which we have referred, tests of the material which cracked showed it to be of first-class quality. Any theory regarding the formation of lap-joint cracks, that may be applied equally as well to all joints of this type, is necessarily wrong, because it is well established that these cracks do not form in all lap joints; nor has it yet been shown that they always tend to form in such joints.

Engineering Accuracy

If any one th ng distinguishes the engineer of experience from one whose reputation is yet to be made it is the sense of proportion in regard to accuracy which comes with practice to the man blessed with mental perspective. To know what is good enough for the purpose is to unlock the doors into many chambers of material reward and to avoid the waste of talents and energy which people with little imagination usually fritter away in useless strivings after unnecessary perfections. Engineering work and the tasks of the research laboratory are blood relations, but in the former nearly always the question of cost is the controlling factor while in the latter it is usually great precision. It is the old story of the difference between pure and applied science, and if the conditions surrounding the engineer are largely commercial in these days, there is nothing to be ashamed of in working within commercial limits of the truth. Many a man takes up practical engineering work in one field or another with little realization of the value of seasoned judgment in determining the proper limits of his striving after accurate results, and sometimes he remains miserable for years because the equipment at his command lacks the precision of his ideals.

Some tasks, like counting barrels of oil, barrows of coal used, and the reading and recording of registering meters, must be exact: there is no place for mistakes or approximations in judgment. Inexperienced men often fail to realize the great importance of doing this kind of work right, a point of view fostered, it must be admitted, by the practice many schools have of giving high credit for the selection of the proper method of solving problems, regardless of the accuracy of the computations. But in innumerable other tasks efforts to carry accuracy beyond the commercial limit defeat their own ends and often invite ridicule or criticism from those who know the real value and limitations of the methods in hand. Examples of such are stating the yearly coal consumption in ten-thousandths of a ton, using decimals in putting down the totals of millions of kilowatt-hours, measuring engine rooms for ordinary data-sheet purposes to fractions of an inch, or carrying out test data to percentages which the apparatus making the measurements could never reach with reliability. Often these may be merely the result of thoughtlessness, but even so, they tend to show that the man responsible for them has not yet become a master of his occupation.

Herein are found the great value of regular calibration of instruments yielding records of significance from the cost viewpoint and the usefulness of checking figures and conclusions submitted to superiors as bases for future action. To err may be human, but to verify voluntarily and to pitilessly check one's own figures on one's own initiative, marks the worker into a class above the ordinary run of mankind, training him for the responsibilities and rewards of the expert.

What shall we say of the engineering accuracy of a recent report to a state commission on the cost of electric-power production in a steam plant in which the quoted daily output divided by the stated total expense for labor, fuel and supplies does not check with the tabulated unit cost? The author took pains enough in this instance to list the number and daily wages of every man on the station payroll, but failed to verify the accuracy of the deductions from the data given, and so the part of the report dealing with the particular plant in question was heavily discounted. Whether an engineers owns a slide-rule or not, there is no question that proper accuracy in the great majority of cases calls for at least rough computations that check the values upon which attention is to be focussed, and in important matters the omission to do this throughout the entire task puts the reputation of the man in jeopardy.

No study can be more profitable than the limitations of accuracy of the tools with which one is provided; the man who knows what he can count upon and what he cannot determine with the facilities in hand not only is prepared to meet every demand upon his resources intelligently, but demonstrates to discerning superiors, by his very knowledge of his limitations, his fundamental reliability and practiced judgment.

In the death of Prof. Victor Dwelshauvers-Dery, of which more extended notice will be found on page 584 the American Society of Mechanical Engineers loses its fifth honorary member within two months.

The other losses, which all occurred in February, are Carl Gustaf Patrik deLaval, John Fritz, Sir William Arrol and Sir William Henry White. Professor Dwelshauvers-Dery was the first upon whom the degree of honorary membership was conferred. He was an occasional contributor to the columns of POWER, his latest writings being discussions of the Clayton method of analysis for indicator diagrams, and of the Duchesne experiments upon the physical properties of superheated steam.

READERS WITH SOMETHING TO SAY

Repair of Large Flange

In the brewery plant of S. Liebmann & Sons, Brooklyn, N. Y., the chief engineer has to look after the machinery of the power plant and in addition all mechanical apparatus in the brewery.

Recently an interesting repair was made on the flange of a large copper brew kettle, 20 ft. high and 18 ft. in diameter. Although this apparatus does not belong to the power-plant equipment, the same method might be used in the repair of any large flange, where, as in this case, it would have required a great deal of time and expense to take the apparatus apart.

Fig. 1 shows the steam blowing out between the flange faces, and Fig. 2 is a view of the same flange after the repair had been made, the crosses showing the limits of the defective part of the joint. The repair was made by taking out one bolt at a time near a leak and inserting

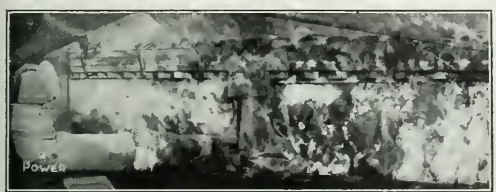


Fig. 1. View of Leaky Flange

into the bolt-hole the force pump shown in Fig. 3. The outlet of the pump appears at the center of the threaded portion. The pump forced a mixture of Smooth-On No. 3 into the leak around the bolt-holes and when as much as possible had been pumped through one bolt-hole, the pump was removed, the bolt replaced and the same operation was performed at the next bolt. This was continued until all the leaks had been stopped.

While the pumping was going on, steam pressure was

Fig. 2. After Repair Had Been Made

maintained in the kettle so that the pump would not force the cement through the flange and in order that the heat from the steam might drive out the volatile matter and harden the cement quickly. The steam was, of course, turned off while the pump was being taken out and the bolts replaced in each case.

In a few instances, No. 1 cement was mixed with water containing a little plastic cement No. 3, and the mixture was calked into the leak from the outside. The kettle was allowed to remain out of commission for four

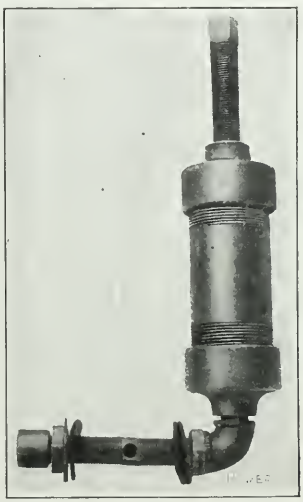


Fig. 3. Pump Used to Inject Cement

days with a little steam turned on, and at the end of that time was put into operation. No further trouble has been experienced from leakage.

Paul Silke.

Brooklyn, N. Y.

Piping Mine-Pump Air Exhaust

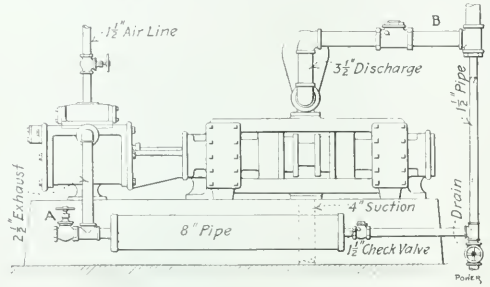
Recently, in a mine where I was employed as machinist, considerable trouble was experienced with the exhaust of a pump freezing, on the 400-ft. level, compressed air being used. The pump would run for a while and then ice would begin to form in the exhaust passages until they were choked, and a man had to keep poking the ice out with a rod to keep the pump running.

It was not practicable to reheat the air, so we resorted to other means. One of the compressor men suggested turning the exhaust into the water-discharge pipe, having seen the idea tried in several places. The 12 and 6 by 13-in. pump worked against a 400-ft. head and the air pressure carried was [illegible] lb.

The exhaust was piped, as shown in the illustration, to a receiver, made of a piece of 8-in. pipe, about 4 ft. long. The exhaust pipe was 2½ in. in diameter with a valve A, so that the pump [illegible] exhaust into the open. The outlet of the receiver was reduced to 1½ in. to cause a steady flow of air into the water-discharge pipe, and was connected to the bottom of the discharge pipe with a check

valve between to prevent water flowing back into the receiver.

When starting up, the exhaust pipe was drained and the pump allowed to exhaust into the open through the valve *A* until water was discharged through the pipe *B* from the pump. Then the valve was closed and the exhaust forced into the discharge-water pipe through the receiver and check valve, the water and air discharging to the surface. This arrangement overcame the trouble and the pump worked with no attention whatever.



Pump Exhaust Piped to the Discharge Pipe

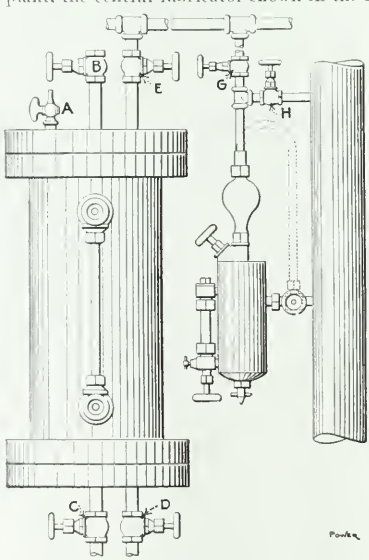
Could not this method also be applied to a pump to be worked under a greater head than that for which it was designed? For example, could a pump designed to work against a 200-ft. head not be made to work against a 400-ft. head in this way?

Walter L. Houston.

Republic, Utah.

Home-Made Central Lubricator

To save the waste of time and oil incidental to the operation of small lubricators on the auxiliaries of a steam-turbine plant, the central lubricator shown in the illustration was made and connected to the small lubricators already in service. This system, which has nine small lubricators connected to the central one, has been in use over four years and given entire satisfaction.



Oil Reservoir Connected to Lubricator

The central lubricator is made of steam pipe, blank flanged at the ends and tapped for the connections shown. The cock *A* is used as a vent when filling the tank with oil, which is accomplished with the aid of a funnel in the valve *B*. Valve *C* is a drain or blowoff, and *D* is the steam connection. Valve *E* is the oil-main connection.

By closing valve *G* and opening *H* the small lubricator can be used independent of the central one. Where single-connection lubricators are to be connected into such a system, a steam bend is slipped out of the nut at its lower end and straightened to form, with its specially built condenser union, part of the oil line; the opening in the nut is stopped with gaskets.

To fill the central lubricator, the valve *E* is closed, then *D* and *C* are opened, then *A* and *B*. After the water has drained out, *C* is closed and the lubricator is filled through *B*. When full, *A* and *B* are closed, and then gradually the boiler pressure is applied through *D*. Finally the lubricator is put in service by opening the valve *E*.

Wilfred E. Bertrand.

Philadelphia, Penn.

Springfield Escapes the Floods

The press reports have indicated in some instances that Springfield was wiped off the map by the recent flood, and in other cases the reports said the city was greatly damaged and the manufacturers put out of business. This is not at all the case, as none of the manufacturers here were injured by the flood, the only damage done being to a few inferior dwellings, and there was no loss of life. The statements sent out have been corrected by the press, but it is doubtful whether these small items will be read by one-tenth of the people who read the former statements. We are receiving many letters of sympathy which would indicate that the exaggerated reports were largely circulated and read, and as Power goes directly to a large number of our customers we would be pleased to have you make known the facts in regard to this city.

We have, of course, suffered from lack of railway facilities, owing to numerous bridges being washed away, and this city has contributed thousands of dollars, and hundreds of our citizens have spent the last two weeks assisting Dayton and other sister cities. All of our factories are running, and the city is in a prosperous condition. As a matter of fact, we are advertising for more skilled labor to take care of the business the manufacturers now have on hand.

The Lagonda Manufacturing Co. and ourselves will, no doubt, be injured by the misleading reports which have been sent out, and if you can do anything to correct the impression which seems to prevail it will be highly appreciated.

John J. Hoppes,
The Hoppes Mfg. Co.

Springfield, Ohio.

[As the most authoritative means of correcting the erroneous impression existing regarding Springfield, we are glad to print this letter from a responsible person at the scene.—Editor.]

QUESTIONS BEFORE THE HOUSE

Factor of Evaporation

In the issue of *The Journal* of the American Society of Mechanical Engineers for November, 1912, the committee on power tests submitted a preliminary report and requested the members to discuss and criticize the recommendations fully.

Among other items which the writer wishes to discuss is the factor of evaporation. Messrs. A. A. Potter and A. L. Westcott have already presented their views through the medium of POWER, and this article is intended as a reply to Mr. Westcott's discussion and in support of Mr. Potter's views. A copy of this paper has been sent to Dr. George H. Barrus, vice-chairman of the committee. Other discussions of the preliminary report will be sent to Dr. Barrus only.

One of the principal objects of a boiler test is to determine the ratio of the heat absorbed by the water to the heat supplied by the furnace.

The heat absorbed may be expressed in British thermal units, or in *equivalent evaporation*, the unit of which is 970.4 B.t.u. The heat supplied may be expressed in British thermal units or in *pounds* of a given kind of fuel.

The results will be unintelligible, or at least indefinite, until both the heat absorbed and that supplied are expressed in the same units. If expressed in different units, the relation between them must be definitely known. No confusion seems to arise when the performance of a boiler is expressed in pounds of *dry* steam per pound of coal, but it will at once appear that a result so expressed is very indefinite. The mind used to dealing with such quantities will grasp an approximate idea of the efficiency of the boiler; but nothing will be positively known, since the heat absorbed will depend upon the absolute boiler pressure and the feed-water temperature, while the heat supplied will depend upon the calorific value of the coal.

To say that the evaporation is 10 lb. of steam from and at 212 deg. F. per pound of coal is more definite, but still does not convey an exact idea. An equivalent evaporation of 10 lb. per lb. of coal whose heat value is 14,500 B.t.u. per lb. expresses the boiler performance definitely. If it were not for the fact that the trade or commercial units, *dry steam*, *equivalent evaporation*, *pound of coal* (or fuel), are so firmly rooted in the minds of most engineers, the writer would recommend that the *performance* of a boiler be expressed only as a percentage. To say that a boiler transmits to the water 75 per cent. of the heat supplied to it is a definite statement and one that is easily comprehended by even a mind not technically trained, while the statement that the *equivalent* evaporation is 10 lb. per lb. of coal is surrounded by something of a mystery to the lay mind.

Mr. Potter's ideas as to the meaning and use of the *factor of evaporation* are correct. If, as Mr. Westcott contends, the *heat of the liquid*, above the temperature of feed water, of the *unevaporated* water or moisture, should be disregarded in determining the equivalent evaporation, why should not the heat of the liquid for the evaporated water or steam also be disregarded. Does he claim that it would be economical to separate the moisture from an engine's exhaust before utilizing the steam in a low-pressure turbine? Does he not realize that 1 lb. of hot water at a pressure of 150 lb. abs., and temperature of 358.5 deg. F. will develop 36,150 ft.-lb. of work in an ideal turbine or engine operating on the Clausius cycle with a back pressure of 1 lb. abs.? He will surely agree that it would at least be economical to return the entrapped moisture to the boilers. While it is true that by disregarding 2 per cent. moisture at 150 lb. pressure an error of only about ½ per cent. will exist in final results, why neglect it at all, however small its amount, when including it will entail no additional trouble or computation?

The writer cannot recall ever having made use of the term "factor of evaporation," preferring to define *equivalent evaporation* as the amount of steam which would be formed from and at 212 deg. F. by the heat *actually* absorbed by the boiler per pound of coal fired.

Thus, if

H = Total heat of the steam, whether wet, dry or superheated;

h = Heat of the liquid corresponding to the temperature of feed;

L_a = Latent heat of evaporation for temperature of 212 deg. F.;

W = Weight of water apparently evaporated per pound of coal;

the equivalent evaporation will be

$$W_e = W \frac{H - h}{L_a}$$

The writer, therefore, recommends that paragraph (b), section 14, of the boiler code, be stricken out, and that paragraph (d) be made to read somewhat as follows:

(d) Equivalent Evaporation. The equivalent evaporation from and at 212 deg. F. is obtained from the expression,

$$W = \frac{H - h}{970.4}$$

in which

W = Apparent evaporation per pound of fuel;

H = Total heat of steam above 32 deg. F. whether wet, dry or superheated;

h = Heat of the liquid corresponding to the temperature of feedwater.

Unless otherwise provided, a combined boiler and superheater should be treated as one unit.

If it be deemed advisable to retain the term "dry steam" or "equivalent dry steam," paragraph (b), section 11, should be modified and made to read:

(b) Corrections for Moisture in or Superheat of Steam. The factor of correction, by which the apparent evaporation must be multiplied to get "equivalent dry steam" is

$$\frac{H - h}{H_s - h}$$

in which

H = Total heat of the steam, wet, dry or superheated;

H_s = Total heat of dry and saturated steam;

h = Heat of the liquid corresponding to feedwater temperature.

Finally, if the "factor of evaporation" is to remain, its definition should involve the *condition* of the steam and be expressed as follows:

The "factor of evaporation" is the ratio of the total heat of the steam, wet, dry or superheated, minus the heat of the liquid corresponding to the temperature of the feed water, to 970.4. And books containing "useful tables" should omit the table of "factors of evaporation."

JOHN S. A. JOHNSON.

Blacksburg, Va.

Collapse of a 14-Ft. Flume

The article on the "Collapse of Fourteen-foot Flume," in POWER for Mar. 18, is of much interest. The theory that the flume collapsed due to unbalanced air pressure is not entirely satisfying. The writer believes that the flume collapsed due to the weight of the water alone and did not necessarily have any help from unbalanced air pressure. A mathematical study of the forces acting in a penstock as it fills with water shows that there would be a large resultant force tending to flatten the pipe. The mathematics establishing these forces are rather complicated and have been omitted. It is sufficient to say that the resultant force would be of such magnitude as to easily cause the collapse of a flume of such large diameter. Before full pressure has been applied to a fire hose the weight of the water will cause it to assume an elliptical shape, and it is this same action which caused the collapse of the flume in question.

A filling of earth to the horizontal diameter would have tended to prevent the trouble. The earth would have supported the weight of the water and balanced the forces set up from this cause. In the case of unbalanced air pressure there would be two effects, that due to the air pressure and the one discussed above. Both act in any case, and which predominates depends on the diameter of the pipe and kind of foundation provided.

M. W. PULLEN.

Baltimore, Md.

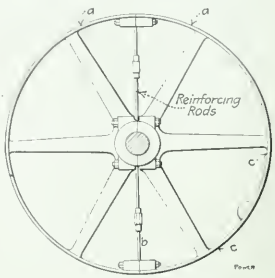
Cast-Iron Pulley Failures

The article in POWER, Dec. 10, 1912, page 848, on the results of the testing of different types of pulleys to destruction, interested me, as it confirmed my observations in actual practice.

Where I am now we have eighteen 84x12-in. cast-iron split pulleys on one shaft. They are of the standard type, held together by clamp bolts in the hub and smaller rim bolts through lugs at the rim joints, and run at a rim speed of 5937 ft. per min.

During the seven years this shaft has been in operation nine, or one-half the whole number of pulleys, have failed in the same ways mentioned in the former article. The first one to fail gave away at the rim bolts, each section containing the lugs and bolts breaking out at *a*, leaving the rest of the pulley intact on the shaft. Not long after, two others gave way in the same place, and then the rest were strengthened by reinforcing rods *b*, extending from the hub to the rim and tightened by turn buckles. The next ones to fail were those which contained the heavy balancing weights, as at *c*. By this time the rods on some of the others were loose and those pulleys began to give way at the joints again. Some would only lose one section of rim; others two sections on opposite sides, but each time either the rim joints or balance weights were responsible for the failure.

One interesting point was that in several of the failures



WHERE PULLEYS FAILED

the 10-in. double belt which ran on the pulleys was not injured or displaced, although it is difficult to see just how the section of rim could get out without tearing the belt.

We have come to the conclusion that this type of pulley is not to be relied upon at that speed, and have replaced those that gave out with pressed-steel pulleys which have proved very satisfactory.

F. P. READ.

Memphis, Tenn.

Putting in New Corliss Valve Stems

In answer to the inquiry by H. W. Lee, in the Jan. 28 issue, regarding putting new stems in his Corliss valves, if the present adjustment of the valves is satisfactory, he need only take the old stems out, place the new ones in the same position as the old ones were and mark them for the keyways.

I have put in a good many new stems and the way I go about it is this:

I remove the back bonnets, and after placing the wrist-plate on the center, fasten it there and gage the distance between the marks at the end of the valves which show the old adjustment, then take out the valves and old stems. The new stems are then put in and each valve set in the same place as before, the cranks are slipped on the new stems, everything connected up, and the keyways marked off from the keyseats in the crank hubs.

If anything has been disturbed in taking out the old stems, as, for instance, the length of the valve rods, everything must be put back in its original position before marking the new stems.

It is quite common for valve stems to become slightly twisted from use and then the valve rods may have been adjusted to compensate for the distortion. It is, therefore, better, when putting in new stems, to look the valve-gear over and see that the valve rods have not been lengthened or shortened too much, and if they have been changed they should be adjusted to their proper lengths before the keyways are marked in the new stems.

F. F. COWDEN.

New Bedford, Conn.

INQUIRIES OF GENERAL INTEREST

Effect of Decreasing Eccentric Diameter—How would the valve travel be affected if ¼ in. was turned off the eccentric?

J. H. L.

Turning ¼ in. off the eccentric would not affect the throw of the eccentric, but the eccentric rod would have to be lengthened that amount.

Humped Back-Pressure Line—If the back-pressure line on a high-pressure card from a cross-compound engine was much higher in the center, what would it mean?

A. L. M.

It would mean that the receiver was too small or the exhaust ports were not opened wide enough.

Detecting Leaking Condenser—When using sea water for condensing steam, how can it be told if the surface condenser is leaking?

W. E. W.

If silver nitrate is dropped into some water of condensation taken from the hot well, the water will turn white.

Boiler-Working Pressure—If a water-leg boiler has stay-bolts pitched 4, 5 and 8 in. apart, which pitch would be used in calculating the safe working pressure?

J. U. P.

A boiler is no stronger than its weakest part and the weakest place, as far as the staying is concerned, is where the stays are pitched 8 in. apart.

Volume of Ton of Coal—How much space does a ton of coal fill?

T. O. M.

A cubic foot of bituminous coal weighs 50 to 55 lb. Therefore, 41 to 45 cu.ft. of space is needed to stow away a ton of 2240 lb. Anthracite coal weighs 55 to 60 lb. per cu.ft., requiring 34 to 41 cu.ft. per ton of 2240 lb.

Leaks Shown by Indicator Cards—How does an indicator diagram show that the valve or piston is leaking?

G. U. Y.

The expansion line will hold up too high if the steam valves leak and if either the exhaust valve leaks, or the piston leaks, the top of the compression curve will show a downward drop just previous to admission or lead.

Added Steam Valve Lap—If more lap is added to the steam valves of a Corliss engine what else is necessary and how are the other parts affected?

C. E. D.

If lap is added on any engine the eccentric must be advanced and this will hasten closure of the exhaust valves and decrease the range of cutoff of the engine.

Compound-Engine Horsepower—How is the horsepower of a compound engine figured?

W. A. R.

Add the products of the area of the high-pressure piston by its mean effective pressure and the area of the low-pressure piston by its mean effective pressure. Multiply this sum by the piston speed in feet per minute and divide by 33,000.

Feed Pump Capacity—If you had a feed pump with 4-in. water end and desired one with twice the capacity at the same piston speed, what size would you order?

G. F. E.

The area of a 4 in. plunger is 12.56 sq.in. Twice this area is 25.12 sq.in., which is the area of a circle very closely 5⅝ in. in diameter. This would therefore be the proper size pump.

Link-Motion Engines—Some engines with link motion will run when the link is in mid gear while others will not. Why is this?

G. L. O.

Because the link is of the open-rod style which increases the lead as it is linked up from the full gear to mid gear, or in short cutoffs, consequently it will run on its lead with light load in mid gear, while with crossed rods the lead decreases as the link block is moved from full to mid gear and this type will not run the engine.

Compound Engine Ratio of Expansion—If a high-pressure cylinder with cutoff at 0.2 stroke is one-fourth as large in area as the low-pressure cylinder, what will be the total ratio of expansion in the high- and low-pressure cylinders combined?

M. A. R.

If the high-pressure cylinder cuts off at 0.2 stroke, the ratio of expansion will be 5 in that cylinder, and since the volumes of the cylinders are as 4 to 1 the total ratio of expansion for the engine will be $4 \times 5 = 20$.

Hot Studs on Circuit-Breaker—What is the cause of the studs on a circuit-breaker becoming hot and how can it be remedied?

M. W. C.

The heating may be due to poor connections causing some sparking or local heating from the high resistance. If improving the contacts does not stop the trouble the studs are probably too small for the current they carry and should be replaced with larger ones. It should not be attempted to pass more than 800 to 1200 amp. per sq.in. of cross-section of copper conductor.

A Lighting Question—A consulting designing engineer states, "The incandescent lighting system may be planned for high-voltage with 240-volt lamps requiring from 30 to 300 per cent. more current than would be required if the system was designed for 115 volts." Is he correct?

J. J. B.

It would seem as though the engineer must have been misquoted. For a given candlepower of lamps the same amount of energy will be required by lamps of either voltage, so the 240-volt lamps would take half as much current as the 115-volt lamps.

Three-Wire or Two-Wire System—What advantage, if any, has a three-wire system (motors, 250-volt, lamps, 125-volt) over a two-wire system with motors and lamps both 250-volt? Why go to the expense of the third wire?

B. J. J.

There is practically no advantage in the three-wire over the two-wire system under the conditions named. The only objections to the two-wire arrangement are in the disagreeable shock from the higher voltage and the greater fragility of the filament of a 250-volt lamp, which renders it less desirable where it is subject to vibration or much moving about.

Running with Broken Steam Valve—If the steam valve should break on a Corliss engine, how could the engine be kept running until repairs could be made?

N. O.

Turn the valve so that it will cover the port and use some means to hold it there. Then disconnect the exhaust valve of the same end of the cylinder from the wristplate and block the valve so that it will stay open. The engine will then run with one end. If it is a single-eccentric engine which cut off at $\frac{7}{8}$ stroke before, it will now cut off at $\frac{9}{10}$ or $\frac{3}{4}$ on the one end. The only difference in operation will be that the engine will not be quite so steady in speed.

Eccentricity of Eccentric—In designing a slide-valve engine with a steam port 1½ in. wide and ¾-in. lap on the valve, the valve to be driven from an eccentric, how far from the center of the eccentric should the hole be drilled for the eccentric to give the proper throw?

P. D. A.

The travel of a slide valve is twice the lap plus twice the port opening; in this case

$$2 \times 1\tfrac{1}{2} = 3$$

and

$$2 \times \tfrac{3}{4} = 1\tfrac{1}{2}$$

the sum of these is 4½, which is the necessary throw for full port opening. The throw of the eccentric, which equals the travel of the valve is twice the distance from the center of the shaft to the center of the eccentric, so that if the hole is bored 2¼ in. from the center of the eccentric it will give the required 4½ travel.

ENGINEERS' STUDY COURSE

Principles of Combustion

Many believe that to understand combustion and other dark matters, such as flue-gas analysis, it is necessary to have a good knowledge of chemistry. This is not so. However, it is easiest as one goes along to have a working idea of a few simple technical terms. Therefore, when you come to paragraphs dealing with dry definitions do not shy around them but wade through. They are there for a purpose and you will be paid for your trouble in the long run.

When an engineer talks about combustion he means the burning of such fuels as wood, peat, the various grades of coal, such as lignites, bituminous coals and anthracite; coke, oil, gases and such byproduct fuels as tar, bagasse, which is sugar cane after the sugar has been extracted, spent tan bark, corn and corn cobs, etc.

The principal element in all of these fuels is carbon which, by the way, is one of the most widely distributed elements in nature. The diamond is pure carbon; sugar contains a large proportion of it; coke is almost pure carbon; paper contains carbon, so does ink; plants, trees, etc., are composed largely of carbon, and even the human being has a large percentage of this element in his make-up.

It is now important to know what an element is. Any gas, liquid or solid which cannot be changed by some process or other which causes chemical change, into two or more substances of distinctly separate natures is called an element. On the other hand, a gas, liquid or solid which can be changed is called a compound. To illustrate, pure iron is an element because there is no way to convert it or "break it up" into anything but iron. Iron-rust, however, is a compound, because it is a chemical combination of iron and oxygen and can be divided by a chemical process into iron and oxygen. Water is a compound because it can be divided by intense heat or by electricity into two gases, hydrogen and oxygen.

These two gases, hydrogen and oxygen, are elements because it is impossible to convert them into anything but what they are. They may, however, be reunited chemically with other elements or with compounds and form many different substances. Air is neither an element nor a compound. It is simply a mixture of elements, mainly oxygen and nitrogen, which may be separated without any chemical change taking place in the mixture.

Although there are thousands of chemical compounds, there are but 79 known elements and nearly half of these are exceedingly rare ones. In the study of combustion, we deal with but the five shown in Table I.

There are two kinds of changes possible in nature, physical changes and chemical changes. A physical change is one that affects the form of a substance but not its character, while a chemical change usually affects both form and character. Two examples of physical changes are the freezing of water to form ice and the heating of water to form steam. While each of these causes the form of the water to change (in one case to a solid; in the other to a vapor) the composition remains exactly the same. If you take a lump of coal and hammer it into a powder you have caused only a physical change, for you have only changed the form of the coal from a lump to a powder which is simply a mass of very small lumps of coal having the same characteristics as the original big lump. But if you burn a lump of coal, it gives off light and heat and the coal changes into an ash and some invisible gases. This is a chemical change because the nature of the substance is completely altered. First you had coal, composed of a large proportion of carbon and small proportions of other substances, such as hydrogen, sulphur, etc. After the change you had left a little ash. The rest of the coal was converted into gases and these passed off into the air.

From this, then, we can describe combustion as a chemical combination of one or a number of combustibles (such as those in Table I), with oxygen (the supporter of combustion), when light and heat are produced.

A fact which is very fortunate from our point of view is this: Chemical elements follow exact laws when they enter into chemical combinations with each other; a fixed weight of one element always combines with a fixed weight of another to form a given compound. Also, a definite amount of heat is always created when a given combination takes place. Thus, when hydrogen, one of the combustible elements of many fuels, burns, it always requires a fixed amount of oxygen; it always causes a certain amount of heat, and it always results in a certain quantity of the product of its combustion.

Because of these facts, Table 1 becomes a very useful thing and in due time you will realize this.

TABLE 1. COMBUSTION DATA

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
Name of Element	Symbol of Element	Combining Weight	Combustion Formula	Compound Formed	Heat Liberated B.t.u. per lb. of Combustible	Pounds of Oxygen Required per lb. of Combustible	Pounds of Air Required per lb. of Combustible
Carbon	C	12	$C+O=CO$	Carbon Monoxide (Incomplete Combustion)	4,450	$1\frac{1}{3}$	5 76
			$C+2O=CO_2$	Carbon Dioxide (Complete Combustion)	14,600	$2\frac{2}{3}$	11 52
			$CO+O=CO_2$	Carbon Dioxide	10,150	$\frac{4}{7}$	2 47
Hydrogen	H	1	$2H+O=H_2O$	Water	62,000	8	34 56
Sulphur	S	32	$S+2O=SO_2$	Sulphur Dioxide			
			$S+3O=SO_3$	Sulphur Trioxide			
Oxygen	O	16					
Nitrogen	N	14					

Carbon

In the meantime, a few things may be said about the elements in Column 1. Carbon being the most important element in most fuels, is placed first on the list and comes first for consideration. In its pure state it is a solid, such as graphite and diamonds. As found in solid fuels, part of it is pure and part is in combination with hydrogen forming hydrogen-carbon combinations which, for brevity, are spelled and pronounced hydrocarbons. The pure carbon part of a fuel is usually referred to as "fixed carbon" because when the fuel is heated the hydrocarbons vaporize and pass off in the air, the same as water in a sponge vaporizes and passes off. The pure carbon remains behind, consequently we say it is "fixed."

In liquid fuel, such as crude oil or any of the products of crude oil, such as kerosene and gasoline, carbon is not found in the pure state but is always present in combinations with hydrogen as hydrocarbons. Carbon exists in gaseous fuels, such as natural gas, illuminating gas, blast-furnace gas, etc., but only in combination with either hydrogen or oyxgen (principally with hydrogen in the shape of hydrocarbons).

When carbon burns completely, it always requires a certain amount of oxygen, and hence, a certain amount of air, because the oxygen is supplied by the air and the proportion of oxygen found in the air is the same in New York as it is in Punxsutawney or San Francisco; in fact, the proportion remains the same the world over. You may supply more oxygen by supplying more air but the excess will not be used. A given amount of carbon will use (or combine with) only so much oxygen, never any more and never any less.

Did you notice in the beginning of the last paragraph that it was said "when carbon burns completely"? Care was taken to specify complete combustion because carbon will undergo partial or incomplete combustion when conditions are not right for complete combustion. But, this need not worry us, because this incomplete combustion also follows definite laws. A certain amount of carbon incompletely burned will use a certain amount of air every time and will give up a certain amount of heat every time. What the oxygen or air requirement is in each case and what the amount of heat is created will be taken up later. Just now we will talk about some of the other elements.

Hydrogen

Pure hydrogen is a colorless and odorless gas. It exists in coal in combination with carbon, forming the hydrocarbons mentioned before. These hydrocarbons form the principal part of the volatile matter in coal. When a coal is heated to a certain temperature, certain quantities of vapors or gases are given off, depending on the nature of the coal. With bituminous or "soft" coals, large quantities are given off; with anthracite or "hard" coals only small quantities are given off. These vapors or gases are known as the volatile matter of the coal. Hydrogen is likewise found in a combined state in the liquid fuels. In gaseous fuels it exists in both the free and the combined state.

When hydrogen burns, it burns completely; there is no part or half-way process with it as is the case with carbon. Hydrogen produces intense heat and as a fuel it has great value.

Sulphur

Sulphur in its pure state is a yellow solid substance which burns very easily and forms a disagreeable smoke. It exists to some extent in practically all coals and fuel oils. It is undesirable in fuel because its heat value is very small and because it tends to form an acid which quickly corrodes the ironwork of flues and chimneys. Sulphur also increases the clinkering properties of the coal. Ordinarily the amount of sulphur found in coal and oil is small, and hence, because its heat value is low, we can easily afford to ignore it in our calculations. It is well to bear in mind, however, that the less sulphur a fuel contains the more desirable it is.

Moisture, Ash, Etc.

In addition to the elements just mentioned, all solid fuels contain water, ash and a few other impurities. The water is usually referred to as moisture. This water cannot be squeezed out like water from a sponge, but it can practically all be dried out from coal simply by heating the coal for a certain length of time. In oil fuel, which also contains moisture, most of the water will settle out when the oil is allowed to stand for a sufficient time.

The amount of moisture which a coal contains depends almost entirely upon the nature of the coal. Some coals are more sponge-like than others; that is, they have greater capacity for holding water than others. The amount of ash or unburnable solid material in coal also varies greatly with the kind of coal, and sometimes the same kind of coal will run very unevenly in this respect. As ash and moisture do not create heat, naturally, the less of these a fuel contains the better it is.

In addition to the ash and moisture, coal contains a few other impurities, principally oxygen and nitrogen. The latter need not worry us in the least because the amount of it is small and it has but slight effect on the results anyhow. The oxygen contained in coal sometimes runs rather large in quantity and hence it is important to know about it, although in our ordinary work in boiler-room economy we can afford to forget about it, and we will, later on, when we "get down to cases." But it is a good idea to get a fair understanding of the whole story so that when we read the more technical articles and reports we will have some idea of what they are all about.

Even the scientists are not certain as to exactly what form oxygen exists in coal. They are not sure whether it is there as an element, that is, as free or uncombined oxygen; or as a compound with hydrogen in the form of water so tightly mixed up in the coal that no amount of heating, short of burning, will drive it out like ordinary water; or whether it is in the coal in some combination with carbon as carbon dioxide or CO_2. However, it is generally believed, and always assumed that the oxygen exists in the coal as a compound with hydrogen in the form of water. Hence, when an analysis of a coal shows that it contains both oxygen and hydrogen, only part of the hydrogen is considered as available for combustion. The other part is considered as being already combined chemically with the oxygen of the coal in the form of water, H_2O. And, as water is noncombustible, the hydrogen thus combined is useless as fuel. Hence, when you see the term "available hydrogen" in a report of a coal analysis, you will know that it means, not

all the hydrogen found in the coal, but only the part which is in excess of the amount required by the oxygen existing in the coal to form water.

Air

Air is composed of the gases, oxygen and nitrogen, and very small quantities of a few other elements and a few compounds. The oxygen and nitrogen form such a large part of the air (99 per cent. or more) that for all practical purposes they are the only constituents to be considered. As found in the air they are both pure, that is, uncombined with any other elements.

Some people have difficulty in realizing that a gas has weight. They think: "You never could weigh a gas; it is too light; it would not stay on the scale." Consequently, they get confused when they read about pounds of air or pounds of oxygen. It is really easy to weigh a gas if you have a good strong tank or cylinder and a pair of scales that are very sensitive and accurate. Suppose you wished to weigh air, for instance. Although air is not a simple gas, but a mixture of the two gases, oxygen and nitrogen, it makes no difference, the action is the same.

Close the valve on the tank, put the tank on the scale and weigh it. We know that the tank is full of air at

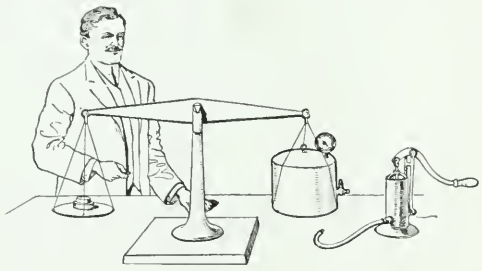


Fig. 1. Experiment To Show That Air Has Weight

atmospheric pressure, because a pressure gage attached to the tank would show zero pressure. Now, connect a good vacuum pump to the tank and pump and pump and pump until the vacuum gage shows as near 30 in. of vacuum as you can get it to show. Then, weigh the tank again. This time the weight will be less, proving that air has weight. If the temperature of the air was 60 deg., if the tank had a capacity of 5 cu.ft. and if it weighed 75 lb. the first time, it would weigh something like 74.618 lb. the second time, showing that the 5 cu.ft. of air pumped out weighed 0.382 lb. or that air at 60 deg. temperature and atmospheric pressure weighs,

$$\frac{0.382}{5} = 0.0764 \textit{ lb. per cu.ft.}$$

(By the way, it was not necessary to close the valve on the tank for the first weighing. But this is another story to be taken up later.)

You will notice that the temperature of the air when the weighing took place was specified. This was done because air (or any gas) is a very elastic fluid and expands and contracts very easily by being heated and cooled; hence its weight per cubic foot changes with change of temperature; that is, unless it happens to be inclosed in some vessel that will not let it expand. Then it is not the volume nor the weight that changes, but the pressure.

If you think of a gas as a very light fluid it is easy to realize that it has weight just the same as any other fluid, such as water.

By volume, air is composed of 21 per cent. oxygen and 79 per cent. nitrogen. That is, out of every 100 cu.ft. of air, 21 cu.ft. is oxygen and 79 nitrogen. By weight, air is composed of 23.15 per cent. oxygen and 76.85 per cent. nitrogen. That is, out of every 100 lb. of air, 23.15 lb. is oxygen and 76.85 lb. nitrogen.

OBITUARY

PHILIP H. DIEHL

Philip H. Diehl, electrical engineer, and founder of the Diehl Manufacturing Co., Elizabeth, N. J., died Apr. 7, at his home in that city at the age of sixty-six. Mr. Diehl was born in Dalsheim, Germany, Jan. 13, 1847. He came to the United States in 1868 and entered the employ of the Singer Sewing Machine Co. In 1879 he invented an arc lamp, and shortly afterward he placed on the market a small battery motor which embraced the principle of the varying air-gap for speed control. In 1884, at the Franklin Institute exhibition at Philadelphia, Mr. Diehl exhibited a dynamo which was modeled somewhat after his smaller motor and which generated energy for arc lamps, sewing-machine motors and incandescent lamps covered by his patents.

In 1887 the firm of Diehl & Co., predecessor of the present Diehl Manufacturing Co., was formed and in the late eighties the Diehl ceiling fan made its appearance. This was claimed to be the first ceiling fan possessing an individual suspended motor carrying its own separate set of blades.

One of the first of Mr. Diehl's inventions in connection with the sewing-machine industry was an individual motor of the external-ring or Siemens type which was made part of the balance wheel of the Singer sewing machine. This balance-wheel motor led to the development about 1890 of a larger motor incorporating many of the features of the smaller design, including the ring-type armature. In 1889 a bronze medal was awarded to Mr. Diehl by the American Institute of New York for electric fans and dynamos.

VICTOR DWELSHAUVERS-DERY

A distinguished scientist, particularly noted for his researches into the properties of steam and its action in the engine cylinder, and for his work for the advancement of engineering education, was Prof. Victor Dwelshauvers-Dery, who died on Mar. 5 at Liége, Belgium.

Victor Auguste Earnest Dwelshauvers-Dery was born at Dinant, Belgium, Apr. 25, 1836. Of aristocratic birth by his mother, he united a delicacy of sentiments to the love of liberty and the energy that he derived from a very democratic father. When seventeen years of age he went to study for four years at the Institute of M. Dupuich, of Brussels, where he specialized in the higher mathematics. His mind displayed a leaning toward the actual and practical, which influenced him to go to the School of Mines in the University of Liége where he took the degree of mechanical engineer in 1861. Directly, he was appointed an instructor at the university, and subsequently became a full professor, succeeding Brasseur, a famous teacher of applied mechanics, under whom he had studied.

There was then little instruction given in such subjects as resistance of materials, graphical statics, thermodynamics and the theory of the steam engine, but they were introduced by Dwelshauvers-Dery into the curriculum. He was anxious to compare theory with practice and devoted much attention to original investigation. At the London Exhibition, in 1862, he was greatly impressed by the Porter-Allen engine and forthwith purchased a novelty which Mr. Porter had shown in connection with it—a Richards high-speed indicator. This the buyer long lacked facilities at his school to use.

From 1870 on, he sought to establish an engineering laboratory for his students, but was a great while in getting it. He visited Hirn, in Alsace, and made use of an engine of that distinguished scientist for investigating the discrepancy between the pure thermodynamometric and the correct, applied theory of the steam engine. Among the

phenomena which he approached by new methods of study at Liége were those of steam condensation. About 1880 he was allowed an appropriation with which he purchased an engine for experimental laboratory work, but at first was obliged to keep it outside of the university, at his own expense. It was not until 1893 that the university granted him the mechanical laboratory he desired. To his influence may be ascribed the fact that steam laboratories were already being established by other institutions. From 1894 systematic work was conducted in his, and it was fruitful of results. The first years of research tended to show the possible usefulness of steam jacketing and of superheated steam and emphasized the importance of dry steam. One of his greatest accomplishments was the determining anew, with an engine of commercial size, the mechanical equivalent of heat.

From 1897, Dwelshauvers-Dery devoted himself entirely to useful in the mechanical laboratory which had been established at the University of Liége. It was his method, when testing an engine, to have all the observations of the instruments made by a group of a dozen students, each having his duties clearly determined beforehand, readings being recorded every minute or every two minutes, etc., in a notebook prepared for the purpose. The test proper did not exceed an hour or an hour and a half, which contrasts with the hours of time generally occupied in such purposes in school laboratories. The test having ended, each observer dictated his notes to the others. The handling of

DWELSHAUVERS-DERY

these data comprised a solution of some 50 numerical problems to be worked out at home.

The method of Dwelshauvers-Dery enables the professor to realize the desire of Hirn, that the students might be made useful in new discoveries. In 1873, he proposed the question: "Is the compression of steam in the clearance space at the end of the return stroke economical?" For purely theoretical reasons, with numerous engineers, he believed in its economy; but he desired experimental confirmation. To solve this and other similar questions, he had constructed a purely experimental engine, which was flexible in its adjustments, permitting at pleasure separate changes of all the events of governing and steam distribution. For example, the degree of compression might be varied, everything else being kept the same. To the great surprise of the professor, a first long series of tests showed that compression was the more costly the more it was prolonged. He was unwilling to believe this until further tests were made with some of the conditions changed.

After having described his method of experimentation, he imparted to the public his researches upon final compression. His articles aroused the praise of some engineers. Some even tried to discredit the laboratory tests at Liége, suggesting that there had been piston leaks, shown by a hook at the end of the indicator diagram. The professor was convinced by experiment that there had been no such piston leak. When put in possession of all the original documents, Commodore Isherwood, formerly engineer-in-chief of the United States Navy, who had decided to take up the question, affirmed the absence of a piston leak. Finally, Georges Duchesne, a pupil and collaborator of Dwelshauvers-Dery, put an end to the discussion of this subject by a decisive experiment.

The professor attributed the hook at the end of the diagram to condensation produced by compression; and gave, as proof, diagrams taken upon Allis engines which showed the final hook and which certainly had not been affected by piston leaks. Duchesne, to settle the question, said: "If the hook be due to condensation it will not appear if we compress air, which is not condensable." He experimented with air and no hook appeared in the diagram.

Dwelshauvers-Dery then demonstrated experimentally that the law of expansion is not the same as that of compression.

Pursuing the investigations, Duchesne decisively showed that generally the steam is superheated at the moment when exhaust ceases and compression begins; that afterward the superheat is lost by the action of the cylinder walls and that, in certain cases, the steam rapidly condenses before the end of the stroke, this resulting in a hook.

Partly, at least, upon the basis of others' investigations, Dwelshauvers-Dery had laid down the following principle, later confirmed by experiment: "The most economical operation of the steam engine is secured when, by an efficient means, whether jacketing, superheating or other, the cylinder wall is brought to a condition of perfect dryness at the beginning of the exhaust period."

A later enunciation was as follows: "The less the quantity of water remaining on the surface of the metal of the cylinder wall at the instant of opening the exhaust passage, the less the consumption of steam by the engine. When the ratio of expansion is varied from one to another extreme of values, it will be found that the measure of steam consumption and of efficiency will pass through a series of values also, giving a minimum cost of power and maximum efficiency of steam employed at a point which corresponds to that at which this condition of final dryness of the cylinder wall is secured."

Hirn's calorimetric analysis of the steam engine was put into systematic algebraic form by Dwelshauvers-Dery.

In 1900 the professor's work was interrupted by his appointment as rector of the University of Liége and after three years he retired. Changes were introduced into the methods employed at the laboratory which, he believed, seriously compromised its usefulness, and theories were advanced which he did not approve. With health recovered after a period of being incapacitated for work, he again appeared publicly as a champion of his convictions. Two controversial letters from his pen were published in 1907 and 1908, in the Bulletin de L'Asson. des Elèves des Ecoles Spéciales de Liége; finally, in 1909, appeared his article on "The Conception of Work." In 1908, he also published in the Revue Générale des Sciences, an article on the "Conception of Mass."

In 1905, in connection with the Mechanical Congress of Liége, he was delegated to prepare a mémoire on the mechanical antiquities of Belgium and especially upon the famous hydraulic machine of Marly, erected under orders of Louis XIV, by Renkin, of Liége. The same year he edited a historical report on the mechanical progress of Belgium from 1830 to 1905.

In 1888 he was awarded by the British Institution of Civil Engineers, the Telford prize for his discussion of the steam-engine governor. In 1889, he shared with Donkin a prize for successfully investigating the thermal action of the interior of the cylinder wall. Among the societies with which he was connected was the American Society of Mechanical Engineers, which made him an honorary member in 1886.

The late Dr. R. H. Thurston, who knew Dwelshauvers-Dery well, held both the accomplishments and the character of the man in high admiration.

PERSONALS

W. G. Freer, chief engineer of the Citizens Central Bank Building, New York City, will, on May 1, become power engineer of the American Locomotive Works, at Schenectady, N. Y.

Nicholas F. Brady was elected president of the New York Edison Co., on Apr. 8. Mr. Brady succeeds his father, Anthony N. Brady, who becomes chairman of the board of directors. He is one of the youngest men in the country to be president of a large corporation. Mr. Brady worked his way up in the company's employ, after his graduation from Yale. He has been particularly interested in welfare work, and was instrumental in establishing a commercial school, an employees' savings and loan association, and a well fitted clubhouse for the men.

SOCIETY NOTES

The Detroit Engineering Society will hold its nineteenth annual meeting and banquet in the Hotel Cadillac, Friday evening, April 18. The meeting will be called to order in the hotel parlor on the first floor of the hotel promptly at 6:30 p.m. for the purpose of electing officers for the year, and transaction of other business. The banquet will be held at 8:30 p.m., and the entertainment committee is planning to make this a splendid occasion. Good speaking and music are provided.

BOOKS RECEIVED

A PRIMER OF THE INTERNAL COMBUSTION ENGINE. By H. E. Wimperis. D. Van Nostrand Co., New York. Cloth; 143 pages, 4½x6¾ in.; 60 illustrations; tables. Price, $1.

SCIENTIFIC MANAGEMENT AND EFFICIENCY IN COLLEGE ADMINISTRATION. By the Society for the Promotion of Engineering Education. Cloth; 226 pages; 5¾x8¾ in.; Price, $1.

STEAM TURBINES. By H. Wilda. D. Van Nostrand Co., New York. Cloth; 191 pages, 4½x7¼ in.; 104 illustrations; tables. Price, $1.25.

New Plant to be Erected at East Chicago, Ind.

The Northern Indiana Gas & Electric Co. will spend $750,000 this year on a new generating plant to be erected at East Chicago, Ind. Work has been going on since December.

The new plant is to be situated at the junction of the Calumet River and the Chicago Drainage Canal. It is designed for a capacity of 40,000 hp., but it is planned that two units of 6250 hp. each will be working by May 1. Transmission lines will be erected to distribute the power from the new station.

A new fuel, called "motor spirit," has been announced by the Standard Oil Co. This fuel is an additional product of petroleum, and doubles the amount of available gas-engine fuel to be obtained from a given amount of crude oil. This is accomplished by a new process, which has been patented by W. M. Burton. It is stated that the new fuel will be sold for 3c. a gallon less than gasoline, and that it will give 25 per cent. more mileage to the gallon than gasoline. It has a greater range of boiling points than gasoline, and therefore allows the motor to be started rather more easily than with gasoline. It is about 5 deg. heavier than gasoline, has a yellow color, and a somewhat strong odor, which could be done away with by a process of deodorization and distillation, but this additional refinement would increase its price. The new fuel has disadvantages in that it causes considerable smoke, and a slight carbonization of the cylinders, similar to that found when an excess of lubricating oil is used. Less lubricating oil is said to be necessary with this fuel, and that it is desirable to clean out the cylinders with kerosene about once a week.

Naval officials estimate that at the end of the present fiscal year 20,000,000 gal. of fuel oil will have been consumed by naval vessels, or 6,000,000 gal. more than was used last year and more than three times the amount used in 1911. These figures are considered important as indicating that the amount to be consumed during the fiscal year 1914 will reach a total of 30,000,000 gal., or an increase of 500 per cent. in three years. Already six battleships and 20 destroyers are burning oil, and this number will be increased by two battleships and eight destroyers next year. In addition to the many advantages which naval experts report on oil as a fuel, it is observed that the United States is the only great nation in the world with an almost inexhaustible supply.

The new 50,000-ton Cunard liner "Aquitania" will be launched at Clydebank, on Apr. 21, next. The new Gladstone Dock on the Mersey, to be opened in July, can accommodate the vessel.

NEW EQUIPMENT

ATLANTIC COAST STATES

The citizens of Chelmsford, Mass., are considering plans for the construction of a municipal electric-light plant.

The Amherst Power Co. has prepared plans for the construction of a power substation at Chicopee, Mass.

The American Printing Co., of Fall River, Mass., is to install a 1000-hp. turbine engine to increase its present power generation one-third.

The construction of a municipal electric-light plant at Paxton, Mass., is under consideration.

The Trenton Gas & Electric Co. will construct an addition to its power plant on New York Ave., Trenton, N. J. Estimated cost, $9000.

The citizens of New Castle, Penn., will hold an election June 3, to vote on the proposition to issue $200,000 in bonds for the construction of a municipal electric-light plant.

Plans are being considered by the Philadelphia Rapid Transit Co. for the construction of an addition to its power plant at Beach and Popular Sts., Philadelphia, Penn. Estimated cost, $250,000. W. L. Maize, Eighth and Dauphin Sts., Philadelphia, is purchasing agent.

SOUTHERN STATES

The Brook Electric Co., of Warwood, W. Va., is considering the construction of an electric-light plant at McMechen, W. Va.

An election will be held May 6 to vote on the proposition to issue $50,000 in bonds for the construction of a municipal electric-light plant and water system at Spencer, N. C.

The citizens of Whigham, Ga., are considering the proposition to issue $6000 in bonds for the construction of an electric-light plant.

The Hawthorne Mfg. Co., Hawthorne, Fla., is considering the installation of an electric-light plant in connection with its establishment.

CENTRAL STATES

Plans are being prepared by the United Service Co., for the construction of a new power plant at Coshocton, Ohio. Estimated cost, $150,000. C. H. Howell is superintendent.

The citizens of Centerville, Ind., recently voted to issue bonds for the construction of a municipal electric-light plnt. W. A. Butsch s twn clerk.

Plans are being considered for the construction of an electric-light plant at Waumandee, Wis.

WEST OF THE MISSISSIPPI

Preliminary arrangements are being made for the installation of an electric system at Weldon, Iowa. Bonds were recently voted for the purpose.

Plans are under consideration for the construction of a new electric-light plant at East Grand Forks, Minn.

The citizens of Fertile, Minn., are considering the proposition to construct a municipal electric-light plant.

Plans are being prepared for the construction of a municipal electric-light plant at Grand Meadow, Minn.

Plans are being prepared for the installation of an electric-light system in Hildreth, Neb. Bonds were recently voted for the purpose. C. E. Sturtevant, Holdredge, Neb., is consulting engineer.

A committee has been appointed by the council to investigate the feasibility of installing an electric-light plant at Lansford, N. D. C. A. Adams is chairman of the committee.

The citizens of Lisbon, N. D., are considering plans for an expenditure of $40,000, for the construction of a municipal electric-light plant.

Bids will be received by the city of Reynolds, N. D., until Apr. 30, for the construction of a municipal electric-light plant. Plans and specifications are on file at the office. M. N. Brathorde, city auditor. Estimated cost, $5000.

The New Salem Electric Light Co. has been granted a franchise to construct and operate an electric-light plant at New Salem, N. D.

The voters of St. Thomas, N. D., will vote, Apr. 28, on the proposition to issue bonds for the construction of an electric-light plant.

The council has granted a franchise to P. A. Prisnal to construct and operate an electric-light plant at Alice, Tex.

Press reports state that plans are being prepared for the construction of a municipal electric-light plant at Ephrata, Wash. Estimated cost, $10,000.

Plans have been prepared by J. H. Cunningham, engineer, for the construction of a municipal electric-light plant on the Clackamas River, near Portland, Ore. Estimated cost, $2,500,000.

An expenditure of $15,000 is planned by the Pacific Gas & Electric Co. for the construction of an addition to its power plant at First and Jefferson Sts., Oakland, Calif. J. H. Hunt, San Francisco, Calif., is purchasing agent.

CANADA

Plans are being prepared for the construction of a municipal electric-light plant at Berwick, N. S. Estimated cost, $15,000.

Bids will be received by M. Peterson, secretary of the board of control, Winnipeg, Man., until May 15, for furnishing two three-phase generators, 500-kw., 60-cycle, 6000-volt, for the new power plant at Point du Bois.

POWER

Vol. 37 NEW YORK, APRIL 29, 1913 No. 17

Firemen—and Firemen

By H. E. Hopkins

[At the recent locomotive firemen's hearing in New York it was said that firemen now work harder than formerly and are not paid proportionately; that on a hundred mile run over 20 tons of coal are handled; that their clothing was scorched by the intense heat; that 14 hours was the average run; that as the Mallets did more work than the older types many engineers were compelled to go back to firing or be laid off.—News report.]

WHEN you're feelin' sort of peeved
'Bout the wages you are gittin',
An' you think your lot's so tough
That your job you'll soon be quittin'—
Ask the fireman on a Mallet
How his trick compares with yours.
Then you'll find what you call tough
Don't be nothin' else but "chores."

If you'd run a hundred mile,
An' you'd scooped up twenty ton;
If you'd bucked a hu kin' fire
On a fourteen-hour run—

If your overalls an' pants
Was aburnin' from the heat—
If your feet was puffed an' blistered
An' you felt wel-nigh dead beat—

If you'd pulled old Ninety's throttle
In her cab for seven years
An' the Old Man laid you off—
Said that Mallet engineers

Did the work of two of you—
If to firin' back you went
'Cause 'twas all that you could get,
An' the wife the kids, the rent—

If just sixty bucks a month
Was the pay for all this labor—
Then! You'd have more cause for grumblin',
Ain't I right about it, neighbor?
I'm not sayin' both ain't hard,
But there's reason to be glad,
'Stid of grouchin' 'bout your job,
When there's worse that might be had.

Commonwealth Edison Co.'s New Station

SYNOPSIS—A mammoth station which will eventually have a capacity of 240,000 kw. As at the Fisk St. station, the unit plan has been adopted, each unit consisting of ten B. & W. boilers and one 20,000 kw. Curtis turbine. Two machines have now been installed, and as the load demands other units will be added.

The newest generating plant of the Commonwealth Edison Co., of Chicago, known as the Northwest Station, is located on a 55-acre tract of land bounded north and south by Addison and Roscoe Sts. and east and west by the north branch of the Chicago River and Sacramento Ave. and North Whipple St. Two blocks west the company has acquired an additional 40 acres, adjoining the tracks of the Chicago and Northwestern Ry., which are to be used as the main coal-storage field for the plant. The location of the plant is a logical one, as it affords the greatest fuel-delivery advantages and the best condensing-water supply compatible with moderate real-estate values and economical distribution of current.

A private electrically operated railway connects the Northwestern tracks, the main coal-storage field and the power houses themselves. Sixty-ton electric locomotives, furnished by the General Electric Co. and of the same type as those employed by the New York Central R.R. for suburban work at New York City, are used for hauling in the coal cars and switching them about the property.

As a precaution against complete interruption of service, the station will be divided into two groups of buildings with an ultimate capacity of 120,000 kw. each. Fig. 1 shows how they have been laid out. The low buildings at the front of each group are for the transformers, high-tension busbars and oil switches. These connect through a covered passageway with the generator house and beyond the latter is the boiler house. Between the two groups will be two coal piles, each served by a gantry crane having a 265-ft. span.

At present only two-thirds of the group of buildings shown at the left in Fig. 1 have been completed and two 20,000-kw. Curtis vertical turbo-generators with the required boilers and auxiliaries have been installed and are now in service. The present plans provide for six such units in each generator house, but, due to the remarkable and rapid progress being made in the design of prime movers, it is quite likely that the completed plant will be considerably different from that for which the plans now provide. The station is laid out on a unit system closely similar to that employed at the company's Fisk St. plant. Each turbine is served by its own group of 10 boilers, which lie in a row at right angles to the longitudinal center line of the generator house, as shown in Fig. 4, which is a plan of the partly completed station and the existing equipment. The boilers for units Nos. 1 and 2, 3 and 4 and 5 and 6 face each other across a wide firing aisle, as shown in Fig. 2, so that one crew of firemen and water tenders can take care of two groups.

Each boiler is capable of economically generating 30,000 lb. of steam per hour. Thus, each group is ample to supply its generator under maximum load and still be large enough to spare a boiler for cleaning or repairs. The boilers are of the standard B. & W. design and each contains 5800 sq.ft. of heating surface. The superheaters, located between the first and second pass, are also of the standard B. & W. design.

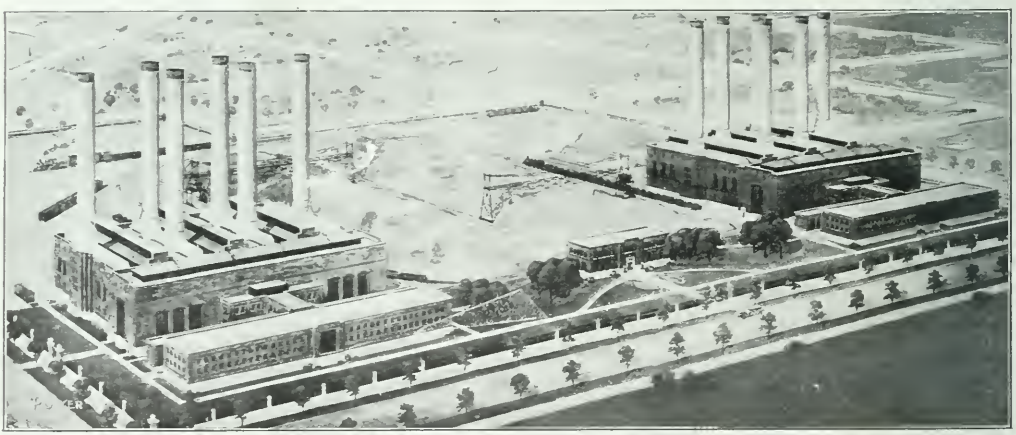


FIG. 1. ARCHITECT'S LAYOUT OF THE NEW NORTHWEST STATION

The boilers are set with a high-combustion chamber. The coal is burned on B. & W. chain grates, which have an area of 115 sq.ft., giving a ratio of grate surface to heating surface of 1 to 50.4. Steam is generated at 250 lb. pressure and superheated 125 deg. F. Each group of boilers is served by its own steel stack, 250 ft. high, above the boiler-room floor, by 17 ft. inside diameter.

One separate and complete coal-handling system is employed for each two groups of boilers. Coal either direct from the mine or from the company's coal-storage piles is run into the boiler house in cars at grade level underneath the fire-room floor, the latter being some 22 ft. above the ground line. The two tracks provided, as

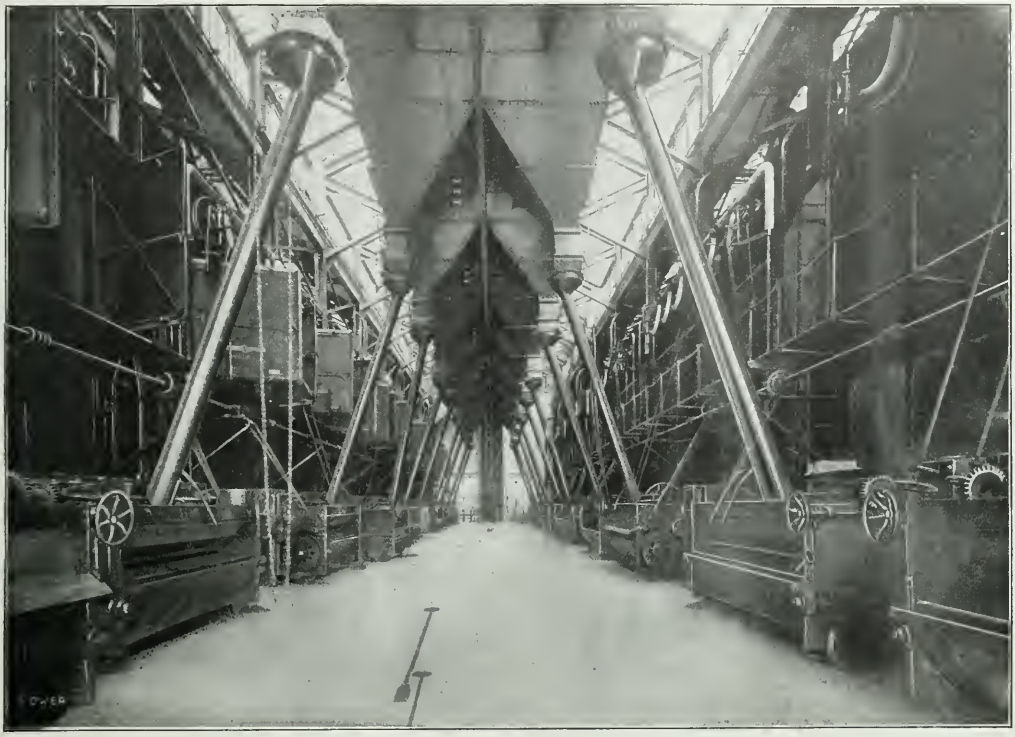


Fig. 2. Present Equipment of 20 Boilers Serving the Two 20,000-Kw. Turbines

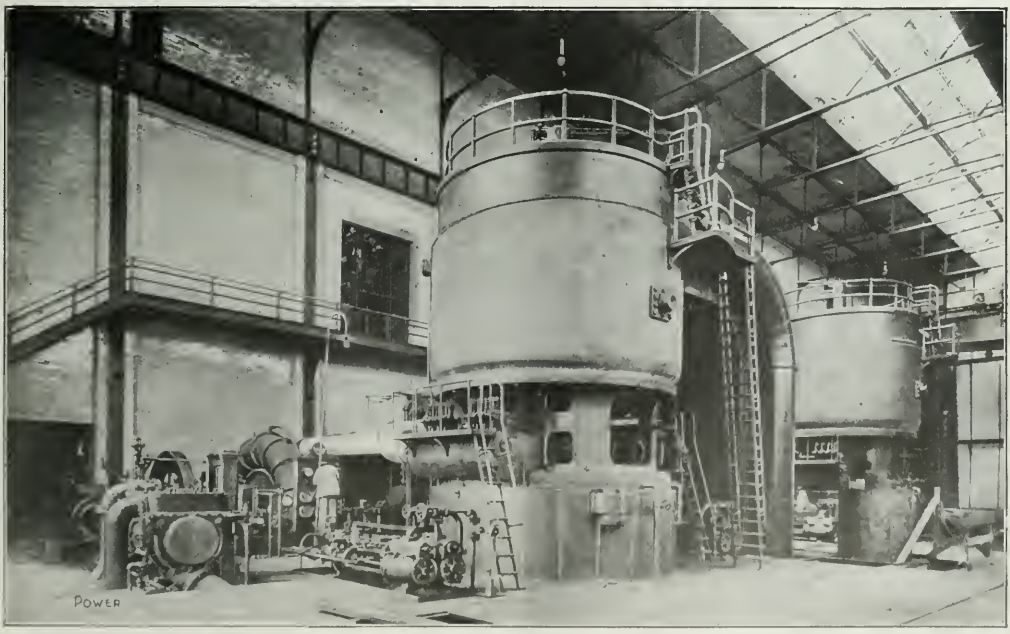


Fig. 3. The Two 20,000-Kw. Six-Stage Curtis Turbines and Auxiliaries

shown in Fig. 6. bring the cars directly over a reinforced-concrete hopper and thus the dumping type of car can be unloaded into the hopper direct. The nondumping cars are unloaded by a traveling crane and a 2-cu.yd clam-shell bucket which drops the coal through an opening provided between the tracks. From the receiving hopper the coal is fed into a traveling crusher which runs on tracks directly over the 34x36-in. buckets of a conveyor. The conveyor raises the coal and deposits it in overhead bunkers located directly over the firing aisle, as shown in Figs. 2 and 6, and from these it is fed through spouts to the stoker hoppers.

The fine coal which sifts through the grates falls through spouts back into the receiving hopper and is again raised to the overhead bunkers by the conveyor. The ashes falling off the end of the chain grates are caught in ash hoppers below, which have a capacity for one day's accumulation. Railroad cars for receiving the ashes are run in under the hoppers and the latter are emptied once each day.

The turbines, shown in Figs. 3 and 5, are of the standard Curtis six-stage vertical type, rated at 20,000 kw. The speed is 750 r.p.m. The exhaust steam drops directly into a Worthington base-type surface condenser containing 7660 one-inch tubes, 17 ft. long, which have a cooling surface of 32,000 sq.ft. The circulating water is drawn from the Chicago River through the lower portion of the double concrete tunnel, as shown in Fig. 5, and discharged through the upper portion This tunnel is large enough to serve all six units in the station. The circulating-water pump for each unit is a 36-in. volute with a capacity of 40,000 gal. per min. against a total head of 20 ft. It is driven by a 20x30-in. Corliss engine at a speed of 120 r.p.m. The dry-vacuum pump is driven by this same engine, the cylinder being arranged in tandem with that of the engine. The vacuum-pump cylinder is 28x30 in. in size. The condensed-water pump is a 5-in. Worthington horizontal two-stage centrifugal driven by a G. E. turbine and having a capacity of 660 gal. of water per minute.

The feed water comes from the condenser at a temperature of about 75 deg. F. and after passing through a closed heater located on the turbine floor and supplied with the exhaust steam from all of the steam-driven auxiliaries, is pumped to the boilers by either of two Worthington three-stage centrifugal pumps driven by Curtis horizontal steam turbines running at 2300 r.p.m. The capacity of each pump is 700 gal. per min. Makeup water supply is controlled by a float valve in the top of the heater.

Steam is withdrawn from the boilers through 6-in

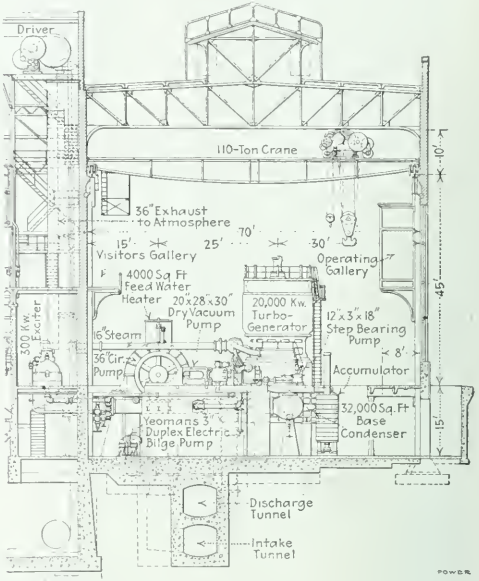


Fig. 5. Transverse Section of Generating Room

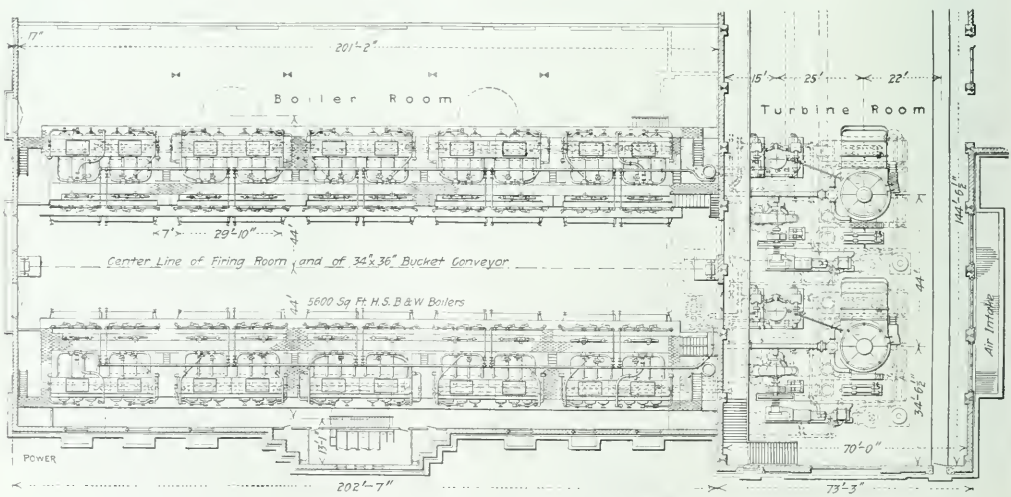


Fig. 4. Plan View of Present Equipment

extra-heavy leads which connect with a 16-in. header for each set of boilers. This header is supported on rollers in a passage at the back of and below the boilers, as shown in Fig. 7. An 8-in. line connects the header of one unit with those of the others so that if need be the steam from one group of boilers can be supplemented with steam from another. The blowoff and boiler-feed

The generator room is finished in white enamel-faced brick and when completed will measure 290 ft. long, 70 ft. wide and 55 ft. high. A 110-ton Morgan Engineering Co. crane spans the room and a railroad track connecting with the outside system extends into the room so that new equipment literally can be delivered in the station.

The weight of the steam end of each unit is 200 tons

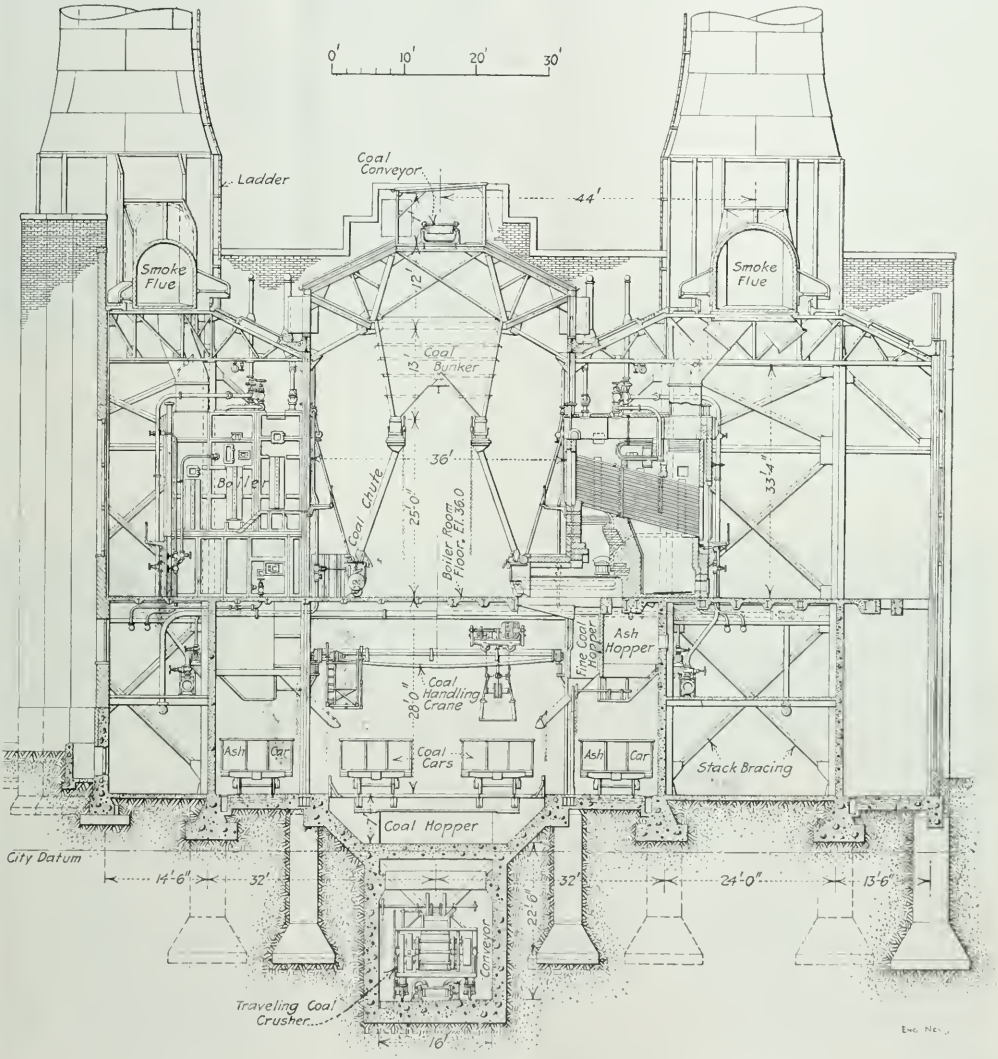


Fig. 6. Cross-Section of Boiler House

piping are also located in the passage mentioned. The safety valves of the boilers blow off through 6-in. risers extending to the roof, as shown in Fig. 8, thus eliminating the danger and discomfort of high-pressure steam discharging into the boiler room.

The current generated is three-phase, 25-cycle and 1500 volts. It is stepped up through autotransformers to 9000 volts for delivery to the substations.

and that of the generator end 230, making a total weight of 430 tons, of which 100 tons is in the revolving elements. This great weight is supported by the step bearing, the two valves of which are kept apart from direct contact by oil forced into the bearing at a pressure of 800 lb. per sq.in. to which the pump pressure of 1200 lb. is baffled down. The step pumps are Worthington, 12 and 3 by 18-in., horizontal, duplex, double-acting, high-pres-

sure units. Floating on the oil system is an accumulator weighted to 30 tons. Should the accumulator sink to a predetermined level, owing to the failure of the steam pump, the auxiliary pump is cut into service automatically.

Forced ventilation of the generator parts is provided by a fan mounted on the main shaft above the generator. The air for this purpose is drawn from the outside of the building through a duct.

In the completed station there will be four exciters, two of 300 kw. capacity each, driven by Curtis horizontal two-stage turbines running at 1500 r.p.m. and generating current at 125 volts and two of 200 kw. capacity each, driven by alternating-current motors at 750 r.p.m. In addition there will be two 70-cell storage batteries, each with 1000 amp.-hr. capacity.

The operating gallery is located in a bay projecting into the turbine room, and from here the operator has a clear view of the entire turbine-room floor. The generator-control switches are mounted on a bench board, Fig. 9, and the line-control switches and all instruments are mounted on vertical slabs above the bench board.

With the advent of the high-speed turbine it was found possible to build a generator whose reactance was only one-fourth or one-fifth of that of the lower-speed reciprocating-engine-driven generators. This was thought to be a highly desirable improvement and the utmost advantage was taken of the new design to keep the reactance as low as possible; but when such generators of large sizes were built and connected to a common set of busbars, it was found that nearly the whole energy stored in the high-speed revolving masses would be instantly hurled into any near-by short-circuit which occurred, the energy output of the machines for the moment being perhaps twenty times normal.

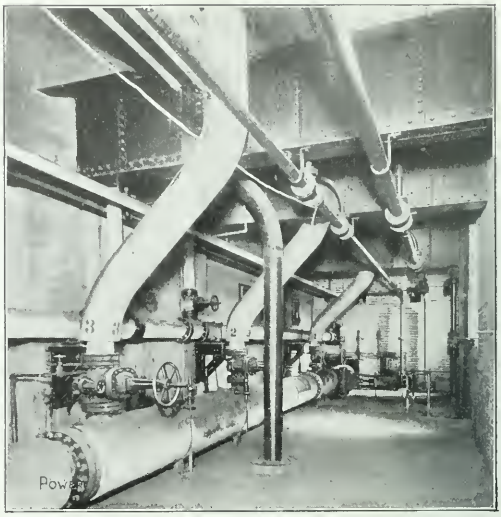


FIG. 7. MAIN STEAM HEADER AND BOILER CONNECTIONS

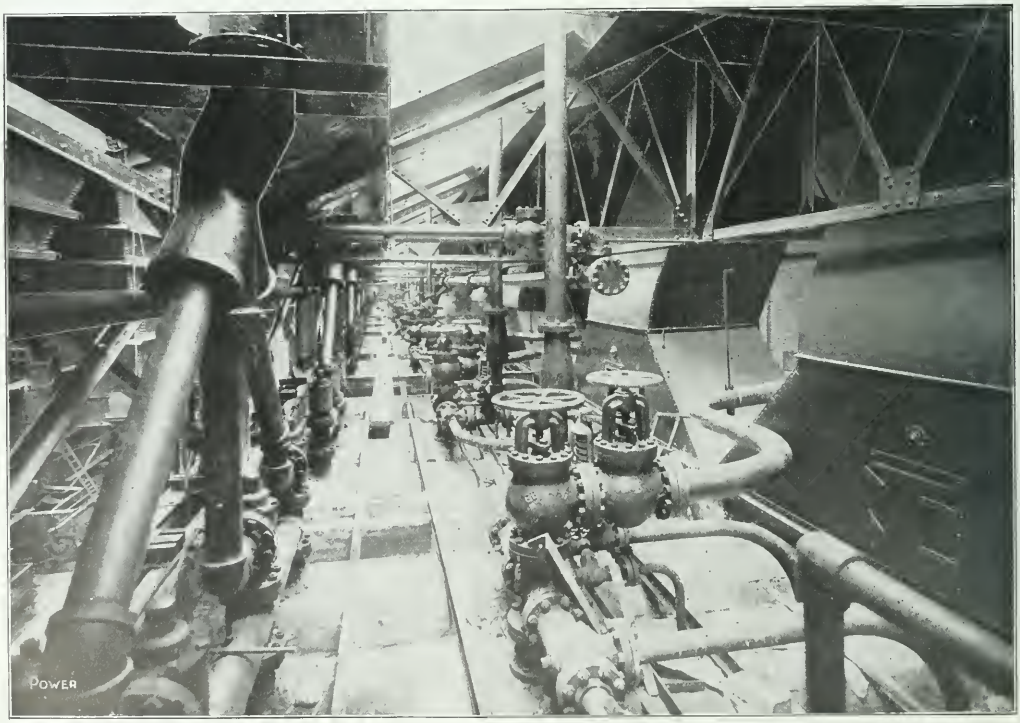


FIG. 8. VIEW ON TOP OF BOILERS

Such violent surges were so destructive to generators, switches, busbars, line and connected apparatus that it was found necessary to restore to the circuit nearly as much reactance as had been gladly eliminated. In the case of the Fisk St. machines this was accomplished by installing in each of the three armature leads to the busbar a 6 per cent. reactance—that is, a coil of cable supported on a concrete and wood frame, whose choking effect, together with the 2 per cent. reactance in the generator, at the full load of the generator, is equal to 8 per cent. of the voltage generated. This effect, which is unobjectionable at normal loads, increases with the square of the current flowing and, therefore, in times of trouble, affords protection which is ample and at the same time automatic. In fact, one of the 12,000-kw. Fisk St. generators was repeatedly short-circuited through a set of these reactances without harm to generator or coil.

At the Northwest station the additional reactance needed was introduced into the circuit in the autotransformers, which step up the pressure from the machine voltage of 4500 to the system voltage of 9000. These transformers are installed in a separate building between the turbine room and the switch house.

Each transformer is installed in a separate fireproof compartment and is of 3333 kv.-a. capacity. They are water and oil cooled and contain 1700 gal. of oil. Water is circulated through pipes immersed in the oil at a rate of 16½ gal. per min. Each tank has an emergency drain, by means of which it can be emptied of oil in a short time. The efficiency of these transformers is 99.4 per cent. at half load and 99.3 per cent. at full load.

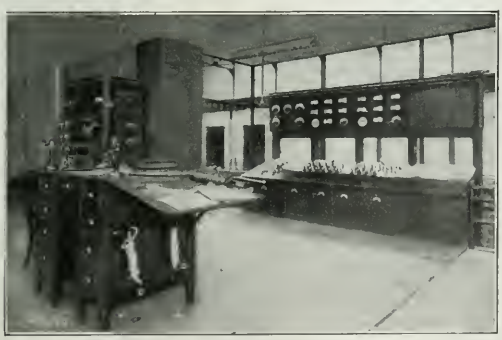


Fig. 9. Control Board on the Operating Gallery

They are 13 ft. high, 9 ft. long and 5 ft. wide and weigh, with the oil, 25 tons.

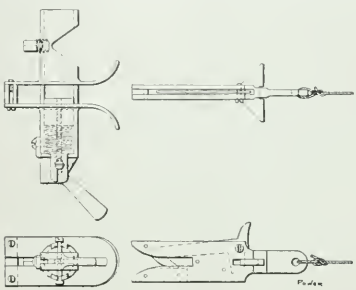
To the east of the transformer house is the switch house, a three-story building containing all the oil switches, high-tension busbars and instrument transformers. On the first floor the busbars, cables, bells and generator leads are installed. The line and generator busbars run east and west, and the main and auxiliary busbars north and south.

The second floor contains the oil switches, the pots of which are built in a single row instead of a double row, which arrangement provides greater safety, in that each oil pot is separated from the adjoining one by a concrete partition. Nineteen switches are provided for each unit, nine of which are bus and tie switches, and two generator switches.

Abadie Indicator Coupling

This device consists of a hollow, cylindrical body, fitted with a setscrew on one end to attach to a pin screwed into the engine-crosshead wristpin. The cylindrical body is made in two sections, joined in line with each other by two pins. The two sections are also separated by two guide plates, bent outward at the outer end to guide the hooking-on member, which is attached to the indicator cord. The outer part of the crosshead member is fitted with a fiber plunger operated by a lever; this is to clamp the hook member in place to prevent endwise movement.

The hook member is of double fiber strips with a metal hook pivoted at one end between the side pieces. The hook is made with a trigger against which the forefinger



Indicator-Cord Coupling

rests when attaching the hook. A crosspiece, or releasing trigger, is also fitted in the body of the hooking member, which, when pressed forward, lifts the hook, disengaging it from the pin of the crosshead member. The details of the device are shown in the accompanying illustration.

When attaching, the plunger is raised by tipping the plunger lever. Then the hook part of the coupling is loosely held between the forefinger and the thumb, letting the hook trigger act as a shoulder against the finger or thumb. It is then advanced in line with the crosshead pin until the hook just touches the pin in the main member; then, by advancing it suddenly about one-fourth inch, the hook engages. Then the plunger lever is tripped back and a diagram taken.

When detaching, the plunger is raised by tipping the plunger lever in the opposite direction. The cord is straddled with two fingers, which are advanced until the releasing trigger is felt; then by advancing the hand one-fourth inch, the hook is released, as the trip trigger comes in contact with the fingers.

The device is the invention of Louis Abadie, Abbeville, La.

⁂

The college graduate is often alarmed at the success of the practical engineer who never went beyond the grammar schools while the college graduate, with medals galore, is still struggling in the ranks. The answer is found in the breadth of imagination, safe intuition and well-balanced judgment of the man who has been treading the practical paths.—"California Journal of Technology"

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The construction of a dam and power plant on the Chelan River, in Washington, to cost more than $10,000,000, is planned by the Great Northern R.R. The road intends to propel its trains over the Cascades by electricity

Troublesome Condensing System

By E. H. Lane

SYNOPSIS—Piping the siphon of each condenser to a common pipe equalized the water pressure and a check valve eliminated a troublesome water-hammer. Cross-connecting the water-supply pipes to the condensers reduced the number of circulating pumps operated before the change was made.

Several years ago a large power house was built having a condensing system consisting of surface condensers A pump house was built at the river bank, about 2000 ft. distant. The pumps were of the single-stage, centrifugal, vertical type and were driven by induction motors. Hence, the speed and the head of water maintained were fixed, varying only with the stage of water in the river.

The first pump installation consisted of four pumps, one having a capacity of 4000 gal. per min., and three of 6000 gal. The three condensers each contained 10,000 sq.ft. of heating surface.

The pump house was connected to the power house by a 48-in. water line, running gradually up hill until the center of the pipe reached an elevation of about 31 ft. It then dropped gradually into the building, the center line of the pipe in the house being at an elevation of 22 ft. The top of the condensers was at an elevation of about 27 ft. and the water was connected at the bottom of the condensers, as shown at *A* in the illustration. The outlet was at the top at *B* and the overflow pipe *C* dropped about 10 ft. and entered the sewer *D* from the under side, as shown. This gave the condenser the benefit of about 10 ft. of siphon effect.

Starting the Condenser

In starting the plant it was customary to keep enough pumps running to maintain a sufficient head so that the water would pass through the condensers by virtue of the head in the pipe. When more water was used it became necessary to utilize the siphon effect of the tail pipe and it was found that one pump would supply the necessary water, as the effect of the 10-ft. siphon was the equivalent of 10 ft. more head with no additional work on the pump. In operation, however, everything would run nicely for a while when one condenser would take all of the water and the other condenser would lose the vacuum and the exhaust would go to the atmosphere. Then it was necessary to throttle the water on the condenser in service and raise the head enough to start the water through the other condenser.

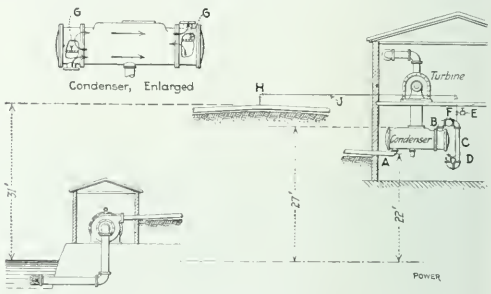
Usually when the water got started through the hot condenser a terrific water-hammer was set up in the siphon outlet and if a fitting was not split during the ordeal, the condenser would take all of the water as the circulating-water valve would be open more than the other and sometimes the condenser with the valve throttled down would lose its vacuum.

Changes Made

It did not take as long to overcome this trouble as it did for the chief to figure out how to do the job. The overflow or siphon of each condenser was simply connected with a 2-in. pipe, with a valve *E* at each connection, so that now the siphon effect on each condenser is the same, as the pressures are equalized by this pipe and the quantity of water is regulated by the head or inlet valve.

The water-hammer was stopped by putting a check valve *F* at the outlet of each condenser at the highest point, the check opening outward so that when more steam or air gets into the siphon than the equalizer can take care of, it blows out of the check. To start the water through a dead condenser, the inlet valve is opened the same amount as when running, and then the valve in the 2-in. equalizing pipe is opened. The water will then go through the condenser just as if the equivalent of the siphon effect in the head was added to the inlet side of the condenser. The condensers were of the single-pass type; that is, the water passed through them once and then to the sewer.

It was found, that, owing to the slow velocity of the water, mud and sand would accumulate in the tubes and it was not long before there was trouble. The chief put



Pump, Piping and Details of Condenser Installation

baffles-plates in the water boxes of the condenser and made each condenser a three-pass unit. Thus the same quantity of water, to get through the condensers, had to travel at three times its former velocity and this made them better condensers.

Everything seemed to be all right and the chief thought he had the condensers anchored and grouted.

Decreased Water Supply

About this time the river began to fall and the pumps obtained water by suction with the usual attendant air leaks. It was then necessary to run all of the pumps to supply the condensers with water. While the drop in the river level would necessarily decrease the quantity of water pumped, the head at the pump house continued to increase and the head at the plant to decrease.

Finally, the chief drilled and tapped a hole for 1-in. pipe in the highest point in the 48-in. pump line and considerable air escaped. At the same time the head at the pump house decreased and the head at the power house increased until finally one pump would supply the condensers with cooling water. A 1-in. line was run from the top in the 48-in. line at *H* and was connected to the 2-in. equalizer line between the condensers.

A connection was also made to one of the condenser air pumps so that any excess air could be quickly taken care of.

It will be readily seen that all air discharged from the centrifugal pumps would naturally accumulate in the highest point of the 48-in. line at *H*. The only way to get rid of the air would be to draw it out from the high point or get enough head at the pump house to compress it and drive it down through the 22-ft. elevation and out through the condensers, which would be practically impossible at the low stage of the river. Why the trouble happened at the low stage was probably because the pumps leaked more air with a long suction lift than otherwise, also that the head was insufficient to drive it out.

More Trouble

Everything seemed to be all right and there was no more trouble until last winter, when the river got low again and there began to be a difference of from 4 to 10 ft. in the water head of the pump house and the power-house head. The 1-in. air line was tested and as it was apparently open it was naturally concluded that it was a friction head, because the pump house had now to supply water for nine condensers of 10,000 sq.ft. of heating surface, take care of 33,000-kw. load, and run one 4000-gal., three 6000-gal. and two 10,000-gal. pumps.

Under these conditions the head at the pump house was 34 ft. and at the plant 25 ft. As a new 48-in. line was being installed alongside of the old, the 2-in. air line was run from the pump in the new line and connected to the equalizer line in the house by the pipe *J*. At the same time it was thought best to run a 1½-in. line over to the old 48-in. line, as perhaps the 1-in. line was a trifle small.

Less Pumps Required

As soon as the 1½-in. line was connected it was found that two 6000-gal. and one 10,000-gal. pumps would maintain a 28-ft. head at the power house, and only 31 ft. at the pump house, thus increasing the capacity of the pumps that much and supplying nine condensers.

Apparently the pump-house power consumption had been cut in two, but such was not the case. A certain amount of water was pumped before and the same amount is being pumped now, therefore, the foot-pounds of work done is the same. The accumulation of air in the hump of the discharge pipe was only the equivalent of a 48-in. valve shut just about so much, and it is one of the characteristics of centrifugal pumps that, as the discharge pipe is choked off, the work of the pump decreases. Thus the work done in either case was about the same, except that, since the discharge was partially closed by this air, it was necessary to run more pumps to maintain the head at the power house. Conversely if the river gets high, a little throttling on the discharge at the power house is necessary or the pumps would take on enough work to damage the motors.

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The Flower Motor Ship Co., Ltd., a $5,000,000 company formed in London to operate lines of cargo vessels propelled by oil engines, has already placed contracts for vessels of 6000 tons for cargo only at present, and contemplates the establishment of regular sailings as soon as the boats are ready.

New Bundy Tilting Hot-Water Pump

This new hot-water pump is designed to handle water of condensation at a very high temperature, and at the rate of approximately 2 ft. for each pound of steam pressure admitted to the bowl.

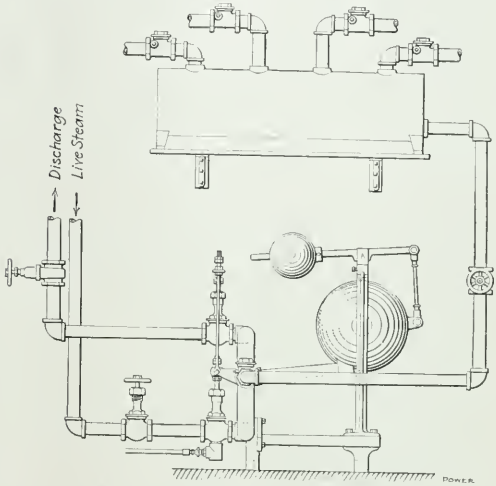


Fig. 1. Bundy Tilting Pump and Tank Connections

When piped, as shown in Fig. 1, condensation may be taken from exhaust-steam lines, returning at atmosphere or below, and raised to any height, discharging into a receiver, heater, hotwell or to a boiler return trap.

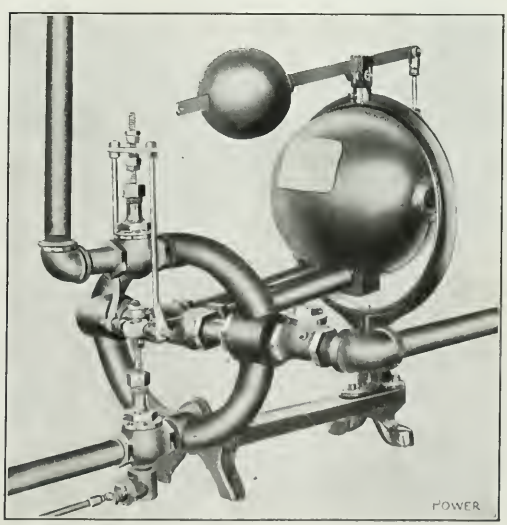


Fig. 2. Bundy Tilting Pump

This pump trap is also adaptable to picking up water from coils or other condensing surface located at a distance from, and returning it back to the boiler room. It is best to place a receiver, in which the water collects,

above the trap, as the water will flow to the pump trap.

The pump trap is designed as shown in Fig. 2. The yoke, usual on tank and return traps, is made with an extension on the upper side, so that the yoke approaches a ring in shape, as shown in the semi-sectional view, Fig. 3. The upper section of the yoke is connected to a discharge valve operated by the tilting of the bowl in unison with the lower, or steam valve. The latter has a vent, as shown in Fig. 2. Referring to Fig. 3, water enters the trunnion *A* in the direction of the long arrow. Live steam is admitted to the bowl through the valve *C* and the left-hand passage of the hollow trunnion. The discharge water passes from the right-hand trunnion in the direction of the short arrows to the discharge valve *B*, the same trunnion is used for the inlet and discharge water.

The operation of the pump trap is understood by referring to the pipe connections in Fig. 1. The water to be handled by the pump trap is returned to the receiver and flows by gravity to the bowl of the trap through the check valve. When the bowl is full of water it tilts to its lowest position, which action opens the steam and discharge valves. Live steam, therefore, rushes into the bowl and the water, being under steam pressure, is forced out through the inlet passage, but, being prevented from returning to the receiver by the check valve, passes through the upper part of the yoke, the discharge valve and the discharge pipe.

As soon as the water has been discharged from the bowl the weight brings it back to the filling position, which action closes the steam and discharge valves, when the cycle of filling and discharging is repeated.

This pump trap is manufactured by the Nashua Machine Co., 127 Federal St., Boston, Mass.

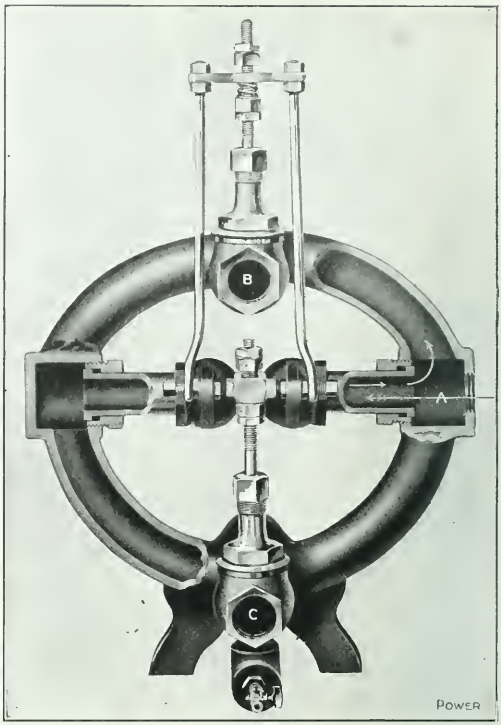


FIG. 3. ARRANGEMENT OF TRUNNIONS AND VALVES

Power Plant Log Calculator*

BY WALTER N. POLAKOV

SYNOPSIS—The construction of the calculator with full directions for its use.

Several years ago, when consulting engineer to the Board of Estimate and Apportionment of the City of New York, I was confronted with the problem to develop a quick and reliable method of figuring the results of boiler trials, efficiency of operation and cost from daily plant logs. The result was the calculator illustrated herewith.

The instrument consists of a logarithmically divided disk (inner scale) centrally revolving on a similarly divided dial (outer scale). The divisions are from 1 to 10 and any multiple of 10. Additional graduations are made for constants for the determination of the thermal efficiency when fuel of different heat value is used. On the outer scale of the dial graduations are made which are constants for the determination of the cost of fuel for the generation of 1000 lb. of equivalent steam. They are based on the cost of 1,000,000 B.t.u. Equivalents for ready interpretation of horsepower and kilowatts in heat units and cubic feet of water at various temperatures into pounds are also marked on the disk and dial. In the center of the disk is a diagram for the determination of the factor of evaporation for saturated dry steam. Instructions for the use of the chart follow:

Weight of Feed Water—Set 10B opposite the Wilcox water meter reading found on the dial. The result in pounds appears on the dial opposite the feed temperature marked on the disk.

Cubic Feet into Gallons—Set 10B opposite the number of cubic feet on the dial. The result in pounds appears on the dial opposite the observed temperature.

Steam Consumption per Kilowatt-hour or Horsepower-hour—Set the kilowatts or horsepowers of output on the disk opposite the number of pounds of steam consumed, read on the dial. The result in pounds per kilowatt or horsepower-hour appears on the dial opposite 10B of the disk.

Fuel per Unit of Output—Same method as above.

Actual Evaporation—Set the number of pounds of fuel, read on disk, opposite the number of pounds of water evaporated, on the dial. The result appears on the dial over 10B of the disk.

Factor of Evaporation—Find feed-water temperature at the left of the diagram in the center of the chart and

*Copyrighted, 1913, by Walter N. Polakov.

follow the horizontal line to its intersection with the diagonal line representing gage pressure; then follow the vertical line down and read the factor of evaporation at the bottom.

Equivalent Evaporation—Set 10B of the disk opposite the factor of evaporation number on the dial. The result appears on the dial opposite the actual evaporation number on the disk.

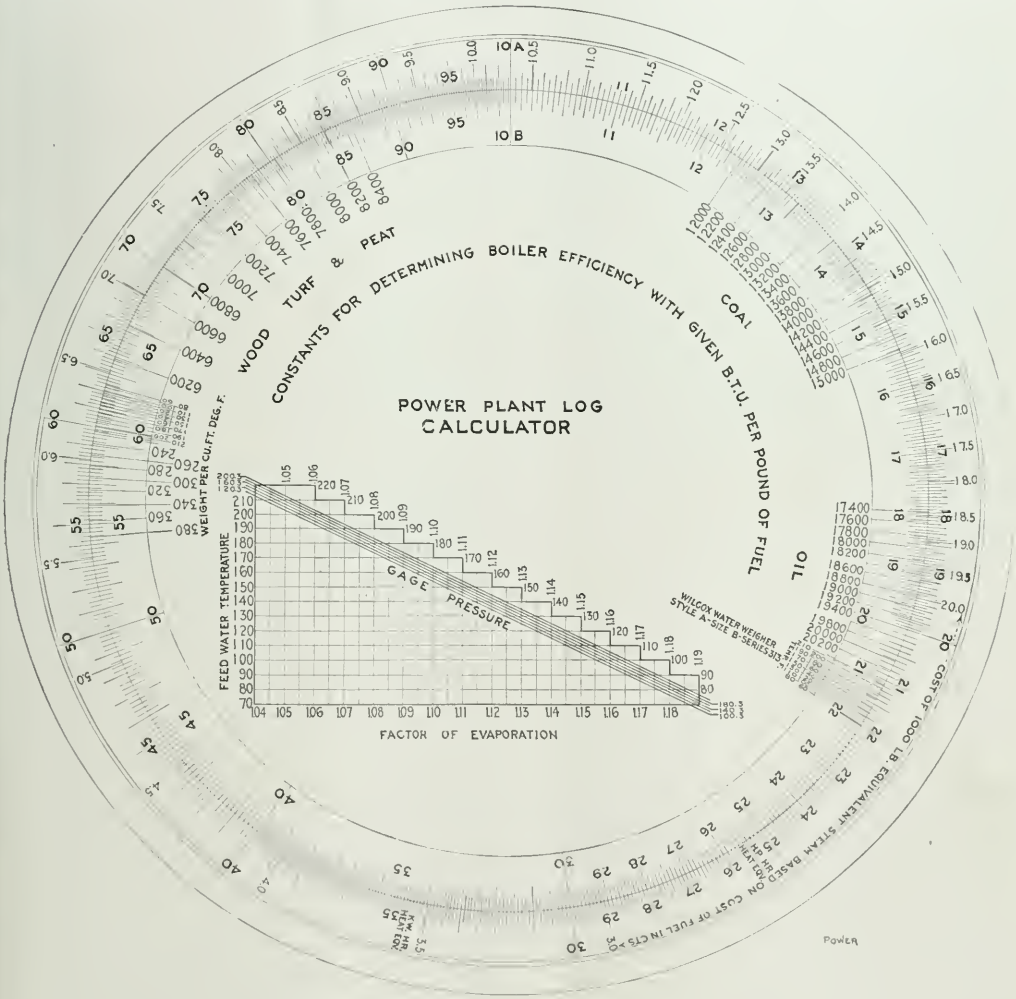
Efficiency of Boiler and Grate—Set the heat-value factor (British thermal units per pound of fuel) shown on the disk opposite 10A on the dial. The result appears on the dial opposite the equivalent evaporation number on the disk.

Cost of 1000 lb. of Equivalent Steam—Set the observed efficiency number on the disk opposite the cost of one million British thermal units in the shape of fuel shown on the outer scale of the dial (which is designated for calculation of cost, but does not show the cost). The result appears in cents on the dial opposite 10B.

Load Factor—Set the number of kilowatts in the peak power load on the disk opposite the number of average power read on the dial. The result appears on the dial opposite 10B.

Thermal Efficiency of the Whole Plant—Set 10B of the disk opposite the constant for kilowatts or horsepower printed on dial. Note the point on the dial opposite the output number on the disk. Set the disk's figure of pounds of fuel consumed under previously located point on dial opposite 10B. Set again the disk so that opposite the point thus found will be the number of British thermal units per pound of fuel used. Do not use constants for the determination of boiler efficiency. The result appears on the dial opposite the 10B mark.

Use as Slide Rule—Any multiplication can be made following the rule for determination of equivalent evaporation and division by following the rule for load factor. All these calculations and others not mentioned can be made quickly and accurately with the calculator.

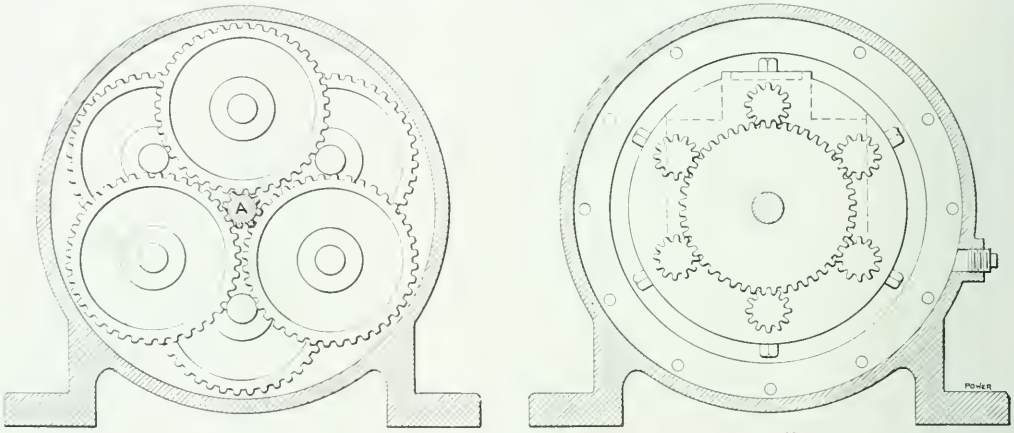

CONSTANTS FOR DETERMINING BOILER EFFICIENCY WITH GIVEN B.T.U. PER POUND OF FUEL
WOOD TURF & PEAT
COAL
OIL
POWER PLANT LOG CALCULATOR
GAGE PRESSURE
FEED WATER TEMPERATURE
WEIGHT PER CU.FT. DEG. F.
FACTOR OF EVAPORATION
WILCOX WATER WEIGHER STYLE A. SIZE B. SERIES 33
COST OF 1000 LB. EQUIVALENT STEAM BASED ON COST OF FUEL IN CTS PER
Power

Novel Reducing Gear

To avoid the excessive stress set up in the teeth of single-reduction gearing and to balance the thrust on the driving and driven shafts, C. H. Clark, of New York City, has invented the reducing gear illustrated herewith. It is adapted for making a large change in the rotative speed where considerable amounts of power are involved.

The pinion A on the power shaft is surrounded by six gears arranged in two planes in sets of three and spaced 60 deg. apart. A shaft from each of the gears carries a pinion on the opposite end and these six pinions mesh with a gear wheel on the driven shaft.

Due to the six contacts the same pinion on the power shaft might safely transmit six times the power, or in transmitting the same power its size may be materially reduced. This reduction in the size of the primary pinion will permit lower surface speeds, and reducing gears of small diameter.



DRIVING END FIG. 1 DRIVEN END

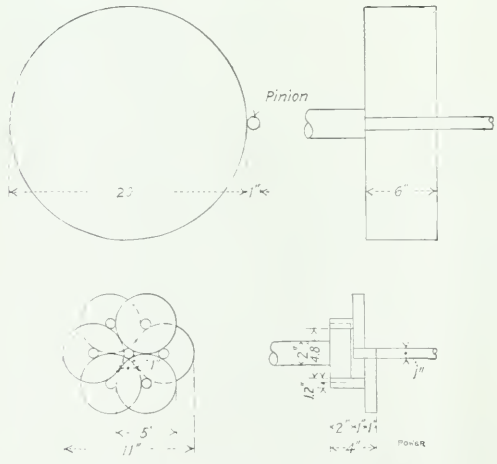


FIG. 2. COMPARATIVE SIZE OF 20-TO-1 SINGLE-REDUCTION GEAR AND CLARK SYSTEM

The comparative proportions of a single reduction of 20 to 1 and the Clark system for the same reduction is shown in Fig. 2. Add to a compact mechanism the elimination of side thrust, and the advantages may overbalance the complication of the device.

The Geared Turbine

In a paper read by C. W. Cairns before the Northeast Coast Institution of Engineers and Shipbuilders, states *Engineering*, the author gave the results of a carefully conducted comparative trial of the "Cairngowan" and the "Cairnross," the former being fitted with reciprocating engines and the other with geared turbines.

Both boats were 370 ft. long, 51 ft. beam, had approximately the same lines and displaced about 10,000 tons. The boiler equipment in each consists of three single-ended boilers, 14.9x10.6 ft., having a working pressure of 186 lb. The "Cairngowan's" engine cylinders were 24, 40 and 66 in. in diameter by 45-in. stroke, and on a 36-hr. test developed an average of 1790 i.hp. The "Cairnross" had a high- and low-pressure turbine geared to a single main shaft, the reduction ratio being 1 to 26.2, developing on the test 1570 shaft horsepower. The propeller speed of each was approximately the same, or 61.7 r.p.m.

These boats were sent side by side over the same course during the 36 hours' trial, and the instructions were to keep in sight of each other during the run. The "Cairnross" consumed 22,000 lb. of coal, the "Cairngowan" 22,700 lb.

Actually, the turbined boat had a very considerable reserve of power, since the pressure at the turbine stop valve was 158 lb. only, as against 175 lb., which was the corresponding figure for the reciprocating engine, and lighter boilers could have accordingly been used for the "Cairnross" without reducing its effective power below that of the "Cairngowan." As special attention was paid to having the hulls of the two ships in a similar state of cleanliness, the results of these very important and interesting trials may be taken as conclusive evidence of the greater efficiency of the geared turbine as compared with good triple-expansion engines.

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Dynamo and Motor Armature Windings

There are two general classes of armature windings: Drum and ring. The names are due to the forms of the cores on which the windings were at first used; the core of a drum armature consisted of thin disks of soft iron mounted directly on the shaft, as in Fig. 152, and the core of a ring armature was (and still is) annular, as represented in Fig. 153. Drum armatures in bipolar machines are still of the type illustrated in Fig. 152, but in multipolar machines they are annular. The chief difference between a ring armature and a multipolar drum armature is in the arrangement of the winding; the windings of all ring armatures encircle the single cross-section of the ring, as represented in Fig. 154, whereas all drum windings embrace the entire core, regardless of its form, as illustrated elementarily in Fig. 155, which represents a coil of four turns on a smooth drum core.

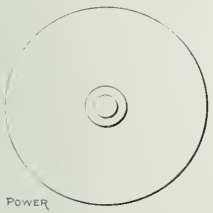


Fig. 152. Drum Core

Fig. 153. Ring Core

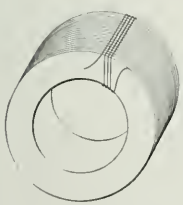


Fig. 154. One Coil of a Ring Winding

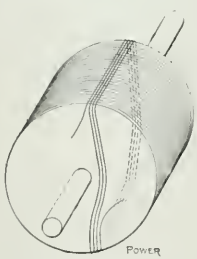


Fig. 155. One Coil of a Drum Winding

Ring armatures have gone out of use in this country, except in a few makes of high-potential constant-current dynamos and some small motors. The winding of this type is connected to the commutator as indicated in Fig. 156, which represents a winding of 16 coils, each containing only one "turn" around the core cross-section. The arrow-heads show the direction of the current and the arrow *R* indicates the direction of rotation necessary to cause the armature current to flow as represented. When the commutator bars connected to any coil pass either of the brushes (when in the position shown), the direction of the current through that coil reverses. For example, when the armature has moved one-sixteenth of a revolution, the coil *A* will be where the coil *B* is and the current will flow through it in the direction of the arrow-head on the coil *B*.

Fig. 157 is a diagram of a drum winding which is the equivalent of the ring winding in Fig. 156. As in that case, each coil consists of a single "turn" or loop, but embracing the entire core instead of one-half of it. There are only 8 commutator divisions or bars, however, and 8 armature coils, as compared with 16 in the other diagram. The reason for this is that in a drum winding each "turn" of a coil includes two stretches of wire along the outer face of the armature core, whereas each turn of a ring winding includes only one wire lying along the face of the core; therefore, for the same number of active wires disposed around the circumference of the core, and the same number of turns per coil, a drum winding requires only one-half the number of coils contained in an equivalent ring winding.

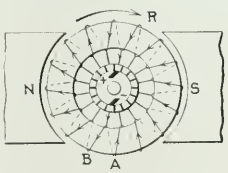


Fig. 156. Ring Winding

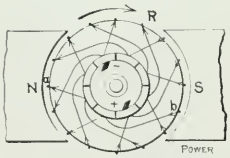


Fig. 157. Drum Winding

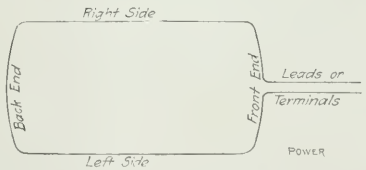


Fig. 158. Names of Drum-Coil Parts

The ring winding has three serious disadvantages in construction as compared with the drum type: (1) The coils cannot be wound and insulated individually without making the core in two or more separable sections, which has been tried out thoroughly and found impractical; (2) it is difficult to mount the armature accurately and securely on the shaft, because the core is entirely covered by the winding; (3) the labor of winding is expensive, because the wire must be threaded through the central opening of the core for every turn in the winding. There is also the disadvantage of sparking at the brushes in machines built to deliver heavy armature currents, under existing conditions of practice in design; but this would probably be remedied if the mechanical construction were sufficiently "workable" to justify the ring type.

The drum type of armature embodies the disadvantage of overlapping coils at both ends of the core. This makes it impossible to repair a damaged coil without disturbing

several other and also makes it necessary to take special precautions to insulate the overlapping portions, to prevent cross between adjacent coil ends.

Fig. 158 is a reference diagram indicating the names of the different parts of a coil; these names apply to all coils for drum windings, no matter what their form or type. The "sides" of the coil are the straight portions which lie parallel with the armature shaft and in which the electromotive force is generated; the "ends" serve merely as conductors from one "side" of the coil to the other.

The principle on which all modern drum windings are constructed is that the two sides of each coil must pass through magnetic fields of opposite polarities at practically the same time. Fig. 159 illustrates this condition

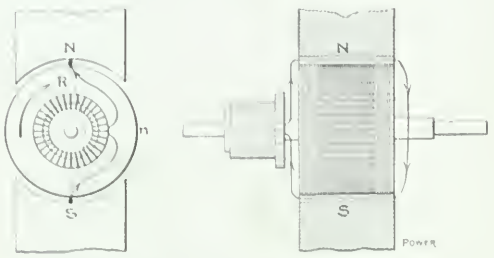


Fig. 159. Relative Locations of the Sides of a Coil. Bipolar Winding

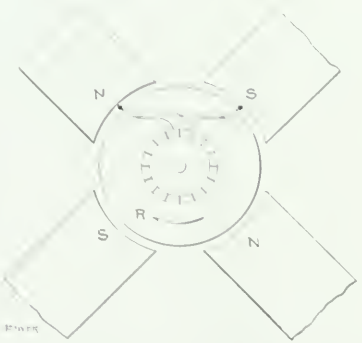


Fig. 160. Four-Pole Diagram Corresponding to Fig. 159

for a bipolar machine and Fig. 160 is the corresponding diagram for a four-pole machine; in both figures the arrow *R* shows the direction of rotation and the arrow-heads indicate the direction of current flow in the wires. It is obvious that when one side of the coil (Fig. 159) moves from left to right under a north pole, the other side moves from right to left over a south pole; consequently, the electromotive forces induced in the two sides of the coil by the north and south magnetic fluxes assist each other in forcing current through the coil. Note that motion of a conductor from left to right *under* a magnet pole produces electromotive force in the same direction as motion from right to left *over* that same pole or one of the same polarity.

If one side of the coil in Fig. 159 were located at *n*, 90 deg. distant from the other side, it would be idle while the other side was active, and the coil would generate only one-half the normal electromotive force. If the coil in Fig. 160 were placed on the core with its sides at opposite diameters instead of at points 90 deg. apart, the electromotive forces induced in the two sides of the coil would oppose each other and, as a result, no current would flow.

In large machines, the armature coils usually consist of one turn each, forming a simple loop. In most other machines, each armature coil contains several turns of wire. Fig. 161 represents a one-turn "lap-winding" coil, Fig. 162 a one-turn "wave-winding" coil and Fig. 163 a "wave-winding" coil of three turns. The terms "lap-winding" and "wave-winding" refer to the manner of connecting the coils to the commutator; there is no essential difference between the coils themselves except in the disposition of the terminals where they lead out from the coil.

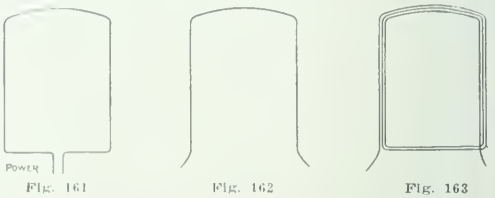


Fig. 161 Fig. 162 Fig. 163

Fig. 161. A One-Turn Lap-Winding Coil. Fig. 162. A One-Turn Wave-Winding Coil. Fig. 163. A Three-Turn Wave-Winding Coil

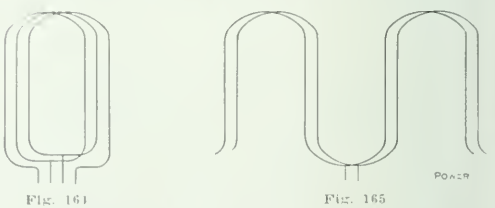


Fig. 164 Fig. 165

Fig. 164. Three One-Turn Lap-Connected Coils Laid Out Flat. Fig. 165. Four One-Turn Wave-Connected Coils Laid Out Flat

The terminals of a lap-winding coil are brought out as close together as practicable and those of a wave-winding coil are brought out as far apart as practicable. The reason for this is that the leads of the lap-winding coil are connected to commutator bars which are close together—usually next to each other—and those of the wave-winding coil are connected to bars which are separated by a distance greater than that between the two sides of the coil.

The lap winding, or, more accurately, "lap-connected" winding, is so named because successive coils lap backward, forming a series of overlapping loops, as represented diagrammatically in Fig. 164. This is a schematic diagram of three one-turn coils of a lap-connected winding as they would appear if taken off the armature core and laid out on a flat surface without disturbing their relative positions. The wave-connected winding progresses continuously around the core, as indicated diagrammatically in Fig. 165, which represents two neighboring pairs of one-turn coils laid out flat.

Light and Power at Panama-Pacific Exposition

A contract for supplying all the electricity, gas and steam to be used by the Panama-Pacific Exposition has been made with the Pacific Gas & Electric Co., of San Francisco. This represents a deal of considerably more than a million dollars, and is the largest that has yet been entered into by the exposition company. It provides for a minimum of 12,000 hp. during the period of construction, which has already commenced, and 20,000 hp. during the actual life of the exposition, which will last from Feb. 20 to Dec. 4, 1915.

An immense generating plant is to be erected on the exposition site on a lot which formerly belonged to the old San Francisco Gas Co., but which has been leased to the exposition authorities free of charge. The plant will serve a dual purpose: Besides generating the power for the fair, it will also serve as the Pacific Gas & Electric Co.'s special exhibit and visitors to the exposition will be shown every process in the preparation of the light, heat, power and illumination which will be used in the greatest exposition in history.

The steam supplied is to be used mainly for heating purposes, and the exposition company, according to the contract, agrees to use 30,000 lb. per hr. between 10 a.m. and 5 p.m. each day during the life of the exposition The streets, which will cover an area of 625 acres, will be lighted chiefly by gas; the wonderful decorative illuminations being effected by electricity.

After the exposition the generating plant will be used by the Pacific Gas & Electric Co. as a substation for supplying individual consumers.

The Pacific Gas & Electric Co. already possesses eleven power houses with a total installed capacity of 96,000 hp., and a new hydro-electric plant which it is building on the Bear River will add 53,300 hp. capacity, apart from the additional capacity in the exposition substation.

⁂

Most Powerful Electric Locomotives

The New York Central is to put in service on the New York Terminal division, ten new electric locomotives which will be the most powerful of their kind in existence. Although weighing only 100 tons, which is 15 tons less than those now in service, they will be more powerful, as the whole weight is carried on the drivers. Normally they will develop 1400 hp. continuously and will be capable of developing as high as 5000 hp. for short periods. They will exert sufficient tractive effort to haul a train weighing 1000 tons at 60 miles per hour.

Each locomotive has eight bipolar motors having the armatures mounted directly on the axles and the field poles carried on the truck frames. The motors are connected permanently in pairs and can be run in three combinations: Series, series-parallel and parallel. Although they will be operated at 600 volts, they are insulated for 1200 volts so that, if at any future time it should be desired to operate at 1200 volts, the pairs of motors could be changed from parallel to series with the same speeds and control combination as at 600 volts.

One of these locomotives has already been thoroughly tested out on the Harlem division, and the General Electric Co. is now filling the order for the remaining nine.

CORRESPONDENCE

Increasing Exciting Current

Permit me to add to the reply to E. J. R., in POWER of Mar. 18, regarding the effect of increasing exciting current on an alternating-current generator. It has been my experience that those operating alternators in parallel often fail to understand the effects of varying the exciting currents on the machines and on that account fail to secure the best distribution of load. Take the case of two machines in parallel with the voltage controlled by an automatic regulator acting on one machine only. In this case the other machine may be made to take a leading or lagging current at will by varying the exciting current, provided, of course, the exciter has the required range. As the power factor of the system is fixed by the character of the load, if the power factor of one machine is raised or lowered that of the other machine moves in the opposite direction.

To illustrate: With a given load and power factor a certain number of amperes must be supplied to the line. If two or more machines of equal capacity are supplying current to the line each should supply the same current, but that supplied by one of the machines can be varied by varying the exciting current on that machine. As a general rule, where two or more machines are supplying current to a line, each machine should carry its share of the wattless current; hence the power factors should be the same on each machine and the operators should see that the ratio of amperes to kilowatts is the same if power-factor meters are not supplied. The number of amperes will be the same only when the load in kilowatts is the same.

In practice many problems arise depending on the types of the generators and prime movers and character of loads. In some instances it will be found that a machine can carry its share of the line load, but is unable to carry its share of the wattless current. In other cases a machine may be unable to carry its share of the line load, but may be able to carry more than its share of the wattless current. Operators should bear in mind that it is the current in amperes that determines the safe load on a generator. If a machine is overheated it may be found to be carrying too much wattless current. In such a case if the exciting current is reduced the machine will still carry the same kilowatts but with less heating. It is, therefore, important that an operator understand that the wattless current may be shifted from one machine to another, though, as stated in the reply to E. J. R., the power factor of the current on the line is determined by the character of the load and cannot be controlled by the generators.

G. E. MILES.

La Jara, Colo.

⁂

A list of testing laboratories is to be compiled by the new Austrian government "Technische Versuchsamt" (Michelbeuerngasse 6, Vienna), says "Engineering News." Private and public testing laboratories throughout the world are asked to send the "Versuchsamt" all pertinent information concerning their field of work, organization, commercial or educational affiliation, equipment, and extent of operations.

GAS POWER DEPARTMENT

Humphrey Pumps for London Water-Works

Special interest centers about the new pumping station of the Metropolitan Water Board near Chingford, Eng., in that the equipment consists entirely of Humphrey gas pumps. Excepting a small plant at Dudley Port, this is the first commercial application of this type.

As London will depend to a large extent upon this installation for its water supply, the action of the water board's engineers in adopting a new type of prime mover may be considered bold. However, it appears that the subject was first gone into very carefully and several methods of pumping were considered.

The low head, 30 ft., and the large amount of water to be handled did not seem to warrant the expense of large reciprocating pumps. On the other hand, the efficiency of centrifugal pumps for this service figured some-

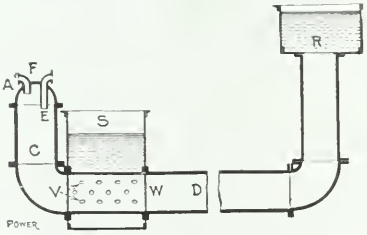


FIG. 1. ILLUSTRATING ELEMENTARY HUMPHREY PUMP

what less than the Humphrey pump. Moreover, it was found that the equipment, consisting of gas producers and Humphrey pumps, could be installed for about $90,000 less than steam boilers and triple-expansion engines driving centrifugal pumps, and that the fuel consumption would be less. The guaranteed fuel consumption with the Humphrey pumps was 1.1 lb. of coal per delivered horsepower-hour, and a penalty of $50,000 was provided for every 0.1 lb. in excess of this. It was further stipulated that should the outfit prove a failure, the sum of $100,000 should be forfeited by the makers of the pump.

The installation consists of four large pumps, each of 40 million gallons capacity, corresponding to approximately 250 hp. against a 30-ft. head, and a fifth unit of half this size. Each has an overload capacity of 25 per cent. The larger pumps are 7 ft. in diameter and the smaller one 5 ft.

The operation of the Humphrey pump was described in POWER over two years ago, but for the benefit of those readers who are not familiar with its operation we will quote from the Dec. 13, 1910, issue:

> Take the simplest case of Humphrey pump, as illustrated in Fig. 1. Water has to be raised from a supply tank S to an elevated tank R. The water-valve chamber W is equipped with valves V, opening inward. In the top of the combustion chamber C is an inlet valve A and an exhaust valve E. A simple interlocking gear is arranged between these two valves, so that when the valve A opens and closes it locks itself shut and releases the valve E, and when the valve E opens and closes it locks itself shut and releases the valve A. Consequently, when suction occurs in the chamber these valves open in turn.
>
> Imagine a charge of gas and air to be compressed in the top of the chamber C, and fired by a spark plug which projects through the top casting. All the valves are shut when the explosion occurs, and the increase in pressure drives

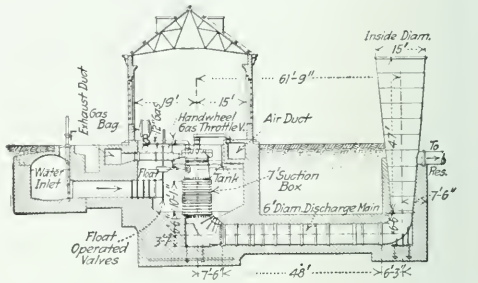


FIG. 2. SECTION THROUGH PUMPING STATION

the water downward in the pump and sets the whole column of water in the discharge pipe D in motion. The column of water attains kinetic energy while work is being done upon it by the expanding gases, so that when these gases reach atmospheric pressure the column of water may be moving with considerable velocity. The motion of this column of water cannot be suddenly arrested, hence the pressure in C falls below that of the atmosphere, the exhaust valve E opens and also the water valves V. Water rushes in through the water valves, mostly to follow the moving column in pipe D, but partly to rise in the chamber C in an effort to reach the same level inside the chamber as exists in the suction tank.

When the kinetic energy of the moving column has expended itself by forcing water into the elevated tank, it comes to rest, and there being nothing to prevent a return flow, the column starts to move back toward the pump and

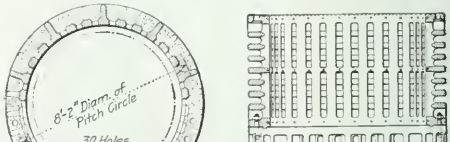


FIG. 3. SUCTION BOX

gains velocity until the water reaches the level of the exhaust valve, which it shuts by impact.

A certain quantity of burnt products is now imprisoned in the cushion space F, and the energy of the moving column is expended in compressing this gas cushion to a greater pressure than that due to the static head of the water in the tank R. Hence, a second outward movement of the column results, and when the water reaches the level of the valve E, the pressure in space F is again atmospheric, and further movement of the water opens the valve A against a light spring and draws in a fresh charge of gas and air. If there were no friction the water would fall to the same level as that from which the last upward motion started, but the amount of combustible charge drawn in is slightly less

*Compiled in part from London "Engineering" and the "Engineer."

than this movement would represent. Once more the column of water returns under the elevated tank pressure and compresses the charge of gas and air, which is then ignited to start a fresh cycle of operations.

Referring now to the present installation, Fig. 2 represents a section through the pump house, showing one of the units and its corresponding water tower; the object of the tower being to take up the surges and maintain a practically continuous flow through the 4-ft. pipe to the reservoir. The water intake is shown at the left leading to the water-admission valves, which are located in a

Considering the sectional view at the top of Fig. 5, the scavenging valve takes its air supply from a central chamber, connected with the air duct, and the fuel inlet is provided with a check and mixing valve and also a supplementary air valve. All the valves are spring operated and open inward. Catches and levers are provided for interlocking the fuel inlet and scavenging valves so that they cannot open together. These also connect through rods (see Fig. 4) to the exhaust valves. The latter, unlike the other valves, are kept open by the springs, but

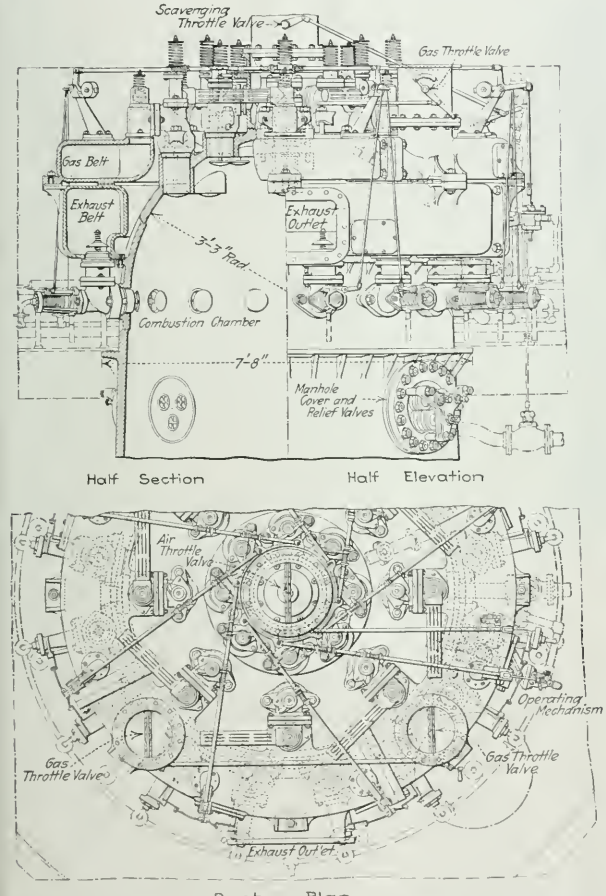


Fig. 4. Plan and Elevation of Pump, Showing Valve Control

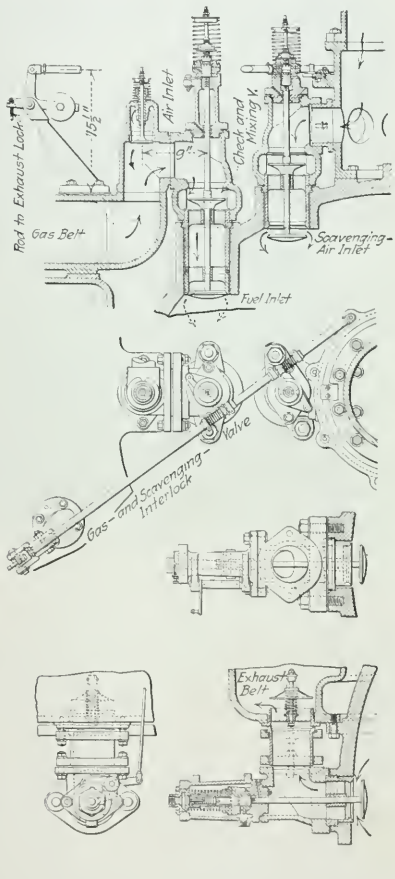


Fig. 5. Details of Valves

ring casting or suction box at the base of the combustion chamber. This is shown in detail in Fig. 3.

The air is supplied to the combustion chamber through an air duct located under the floor (Fig. 2). A blower is provided for supplying this air under pressure for scavenging when operating at an overload, but as yet it has not been found necessary to use this blower. As the pumps exhaust at nearly atmospheric pressure, their operation is practically noiseless.

Fig. 1 shows a plan and elevation of the combustion chamber with its numerous valves, and Fig. 5 shows these valves in detail.

are latched shut during the suction strokes. There are eight sets of fuel and scavenging valves and sixteen exhaust valves per unit, and the rods all lead to a central ring, which permits moving all simultaneously.

On the first (explosion) stroke all the valves are closed until the suction becomes great enough to open the scavenging air valve. On the second (return) stroke the exhaust valves must be open to permit expulsion of the bulk of the exhaust gases. On the third stroke the scavenging valves must be kept closed and the fuel valves must be free to open automatically. All the valves must be closed on the fourth, or compression stroke. This

locking is effected by means of an operating cylinder and oscillating piston connected with the combustion chamber.

The exhaust valves are provided with dashpots to prevent chattering.

Ignition is of the make-and-break type supplied by storage batteries and is actuated by a piston raised by the water pressure during the compression stroke.

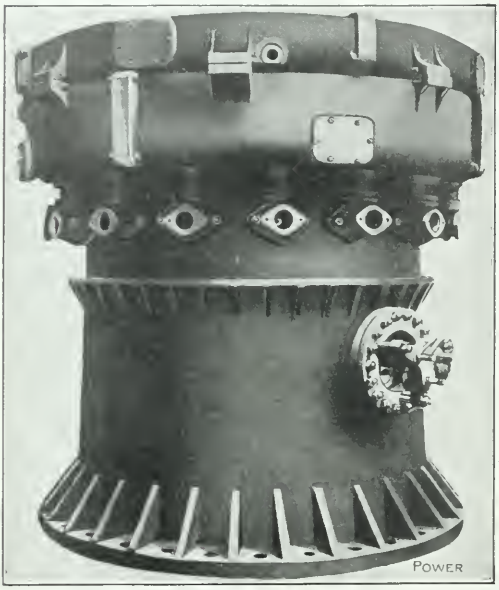


FIG. 6. COMBUSTION CHAMBER OF HUMPHREY PUMP BEFORE INSERTING VALVES

The gas is supplied by four Dawson anthracite producers located in an adjacent building. From the producers the gas first passes to a coke and sawdust scrubber, thence to the holder, and finally through large cylindrical gas bags to the pumps.

Record of a Suction Gas-Producer Plant

BY GEORGE W. MCTENCH

Engineers are always glad to get actual records of gas-power plants that have been in operation for some time, to ascertain what success their fellow operators are having. The following relates to a plant located in Seattle, Wash. This gas plant was put into service, May 10, 1911, and was operated continuously until November, 1912, the fire in the producer never having gone out nor been drawn during that period. The plant was shut down at the latter date for reasons entirely foreign to its operation and which are not necessary to mention here; it suffices to say that the plant gave complete satisfaction.

The producer was built by the Schmidt Gas Power Co., of Olympia, Wash., and is of 100 hp. capacity, furnishing gas for two engines. Although classed as an updraft producer its construction is such as to make it practically a combination up and down draft. The gas outlet consists of a large water-cooled tube passing down through the top of the producer and through the fuel to within 2 to 2.5 ft. of the grate, so that all the gas above the lower end of the tube has to pass through the hot fuel on its way to the engine; this makes it really a double-zone producer. The grate is in three sections; each section can be rocked independently of the others, and the entire grate can be rocked as a whole. This makes it possible to remove the ashes in a comparatively short time.

The washing apparatus consists of a centrifugal scrubber only, no tower scrubber nor dry scrubber being employed. The centrifugal scrubber when running at 1100 to 1200 r.p.m. washes the gas satisfactorily. A motor for running the washer, and a small tank to catch the waste water and tar completes the producer equipment, except, of course, the coal-handling apparatus.

Both engines are of the two-cylinder vertical type, one a 50-hp. Fairbanks, Morse, and the other a 28-hp. Nash. The former was belted to an ammonia compressor and the latter to a generator. The Fairbanks, Morse engine ran continuously 24 hr. per day, from May 11, 1911, to Dec. 1, 1911, and from March, 1912, to Oct. 1, 1912; the Nash ran only from 8 to 10 hr. per day and did not run every day. The former had to carry an overload almost all the time, while the latter often carried as much as 38 hp. for an hour or two at a time. The chief source of trouble during the entire run was the overloads on the engines, there being no relay power and, therefore, no time for overhauling.

The Fairbanks, Morse engine was equipped with a Detroit forced-feed lubricator and filtered oil was used with this, even for the cylinders. The Nash engine having splash and forced lubrication, the oil was not drawn from the crank case until it was too dirty for filtering, when the crank case was refilled with new oil. By this it is not meant that the oil was allowed to get decidedly foul, but at the same time, it was hardly worth filtering. The oil consumption was about 50 to 60 gal. per month, including that used for all the motors and other machines, except the compressor.

Waste water from the ammonia condenser was used for jacket cooling, and connections were so made that city water could be used directly when necessary. Occasionally city water was turned into the jackets to clean them thoroughly, as the water from the condenser pan was rather dirty. Only once was trouble encountered, and that was clogging, due to floating matter in the condenser water, rather than actual scale formation. The Nash engine jacket-water temperature was kept at 150 to 160 deg. F. and that in the Fairbanks, Morse engine from 120 to 140 deg.

The fuel was cheap lignite costing $2.10 per ton (pea size) f.o.b. at the plant, including unloading, and nut size costing $2.85 in the bin. We used both, and part of the time mixed pea and nut. In two instances, owing to delay of shipment, we were forced to use lump size pounded small enough to pass through the producer hopper. This did not give as good satisfaction as either the pea or nut, and required more frequent and harder working of the producer: it also gave more clinker trouble. There was little difference between using the pea and the nut coal expect that it was necessary to use a little more of the former. However, it was easier to handle and

made the producer easier to work. Very accurate records were kept of the fuel consumption. The best month showed a consumption of 1.75 lb. of coal per b.hp.-hr., although the average consumption was about 2.5 lb. per b.hp.-hr. The fact that the night load was only about 55 per cent. of the rated capacity of the producer had a tendency to keep the fuel consumption high.

The lignite used contained from 12 to 20 per cent. moisture and occasionally even more, and it averaged about 15 per cent. ash. The heat value ranged from 7000 to 9000 B.t.u. per lb. as fired, but seldom as high as 9000.

When the gas plant was first started the producer was worked every 6 hr. and sometimes oftener. Later, however, it was worked at 8-hr. intervals, except occasionally the fire zone became too deep and then it required a little extra attention. Also now and then the fire would require a little poking from the top to check the formation of clinkers.

Each working consisted of poking the fire and breaking the clinkers from the top as much as possible, removal of the ashes and charging the producer. The entire process of poking, removal of clinkers and removal of ashes from the grate and ashpit usually took from 25 to 60 min. when everything was in good condition. Only one man was required to take care of the engines and producer, and on the night shift he also took care of the entire plant, including boiler, ice plant, etc.

Except for occasional clinkering, due to bad coal or insufficient steam, the producer gave very little trouble. In the winter, when the plant was shut down each evening, a little air was allowed to pass through the producer, then the next morning it would require only 10 to 15 min. to get the engine started and the load on. We first tried shutting off the air entirely, but found it would take from 30 to 45 min. in the morning to blow the fire sufficiently to get gas rich enough for the engine.

Steam for the producer was obtained from a 40-hp. boiler, which was also used for heating hot water, etc.; this was entirely independent of the power plant. A ¼-in. pipe line under 30-lb. steam pressure led to the producer, but the valve at the boiler was never opened more than half a turn.

For blowing the fire, the tar extractor was used. This drew air through the producer and purged the gas through a special starting purge pipe located just above the tar extractor. The motor driving the tar extractor was driven by city power when the Nash engine was not running.

Most of the engine troubles were of a minor nature. Occasional difficulty was experienced in starting the Fairbanks, Morse engine, because it had to be started with some load, it having no clutch to throw out the ammonia compressor. This was bypassed when starting, but, nevertheless, there was always some load to start against. Another thing that required careful attention was that when the engines were overloaded, they were sensitive to slight changes in the quality of the gas so that it was necessary in working the producer to keep the gas from getting too weak. When either of the engines showed signs of slowing down we would stop working the producer for 5 or 10 min., and when the engines picked up, would finish working the producer.

Usually lignite producer plants have considerable trouble from tar. When first starting the plant we did not have the tar extractor running fast enough, hence, encountered some trouble with the valve stems sticking and the valves chattering. The chief trouble was with the intake-valve stems on the Nash engine. After shutting this engine down in the evening, unless we worked the valves up and down and lubricated them freely with kerosene and oil, they would be found stuck the next morning and hard to loosen. After speeding up the tar extractor several hundred revolutions we had no more trouble.

Daily reports were made, accurate records being kept of the consumption of fuel, lubricating oils, kerosene, gasoline, waste and city water. Load readings were taken every two hours. The stops of each engine were recorded as was also the cause of each stop. At the end of each month a monthly record sheet was filed which showed the consumption of fuel, oils, supplies and the coal used per brake horsepower-hour. Besides actual cost of operation these reports aided in locating troubles and also gave the engineers special interest in the work, as they always were working for a record month.

The record of this plant brings out several points of special interest. First of all, the Fairbanks, Morse engine carried an overload of about 25 per cent. almost continuously during its two runs of seven months each, with no opportunity for overhauling except during the winter. Another point worth noting is that the Nash engine occasionally carried a 40 per cent. overload for about 2.5 hr. The producer responded to all variations in load, and in spite of several exceptionally poor shipments of coal, it was never necessary to draw the fire during the entire run. When the plant was shut down and the fire drawn the brick lining in the producer was found to be in very good condition.

Removing Piston Rings

Mr. A. L. Brennan, Jr.'s method of removing and cleaning piston rings, which appeared in the Apr. 8 issue, would not do if he were in a plant that could not spare an engine very long. He speaks of removing carbon deposits with strips of emery cloth. Upon removing rings, I have found deposits of carbon in the grooves ⅛ in. thick that required a cape chisel and hammer to dig out. Kerosene is all right for softening carbon if the part can be soaked long enough, but in a power plant time is usually important.

With reference to replacing the rings, he says it is advisable to place the top ring first and so on down, but I have found it to be easier first to put on the rings with the liners or strips to carry the ring to the groove.

J. W. Fries.

Ft. Wayne, Ind.

There is a tiny hamlet in southern Alaska, called by the natives Katalla, boasting of a few hundred inhabitants, which really knows what the high price of coal means. Each and every ton burned in that town costs exactly $21.75. And within 25 miles is one of the richest coal deposits in the world. It is the famous coal region about which the Pinchot - Ballinger - Cunningham - Guggenheim controversy was waged. The Federal government now controls those deposits, and the inhabitants of Katalla are prevented, through this control, from mining their fuel needs, which total only 60 tons annually, and are forced to depend upon fuel mined many hundreds of miles away.—"Wall St. Journal."

HEATING AND VENTILATION

District Heating by Steam and Hot Water

By L. B. Lent

The advantages of heating one or several blocks of residences or business buildings from a central heating station are fairly well known. It is obvious that even where supplying heat is the only consideration a higher degree of economy in its generation at least could be attained in a large central plant where coal could be burned under economical conditions, where the labor required is reduced to a minimum, and where economical operation in general can best be had. The principal disadvantage of district heating is that it requires in most cases an extensive and costly system of piping and conduits, and in some cases also requires the purchase of a franchise for laying conduits in the streets or public highways.

When heat is furnished to a group of buildings from a central station in which a considerable amount of power is also generated, the two duties may then be profitably combined. Especially is this true of a central lighting and pumping station. In a power plant using steam as the motive power, where condensing water is costly, it is even possible to make the heating end of the power plant a condensing system for the steam engines and other steam apparatus.

To make an accurate calculation of the amount of heat necessary to supply a given amount of radiation already installed, or that which is to be installed, the compilation of the individual requirements of each customer must be made, but this amount may be estimated with a fair degree of accuracy by estimating the cubical contents of the buildings to be heated and allowing about one square foot of radiation for each 70 cu.ft. of volume.

The consideration which governs a choice between steam and hot water may be stated as follows: The first cost of the plant installed is in favor of the steam system, when it is not equipped with heat control. The cost of operation is usually in favor of the hot-water system, if heat is supplied from the exhaust of steam apparatus and especially if in heating the water with exhaust steam more or less of the steam may be condensed and the engine run under partial vacuum. The cost of circulating mains is in favor of hot water when forced circulation is employed, and besides the steam temperatures are usually higher, so that radiation losses will be greater than for hot water. Where the area supplied is comparatively large and exhaust heat from the engines is available, a consideration of all features indicates that hot-water circulation will be preferable.

Steam System

The sources of heat for the steam system are exhaust steam from engines, pumps or other steam apparatus, and live steam from boilers. While steam heat is classified under two general heads, high pressure and low pressure, it is common practice to reduce high-pressure steam to 30-lb. gage or less before introducing it into the line. Where exhaust steam is used direct, it is seldom good practice to run the pressure above 10-lb. gage, because of the reduced efficiency of the engines from this high back pressure. The amount used for heating purposes is the total heat of the steam above 32 deg. F. less the total heat in the condensation returned from the radiators. The temperature of the return condensation varies but is seldom less than 180 deg. F.

With exhaust steam it is necessary to ascertain the total heat of the steam under the conditions at which it is available. This may be done by assuming that it is equal to the total heat of steam entering the engine or pump cylinder, less the heat equivalent of the work done, and a further subtraction for radiation and condensation losses in the engine. An average value of the total heat in the exhaust steam may be safely assumed as 85 per cent. of the total heat of the live steam delivered to the engine. If the thermal efficiency of the engine is known the calculation of the available heat in the exhaust steam can be more accurately made. Of the total heat furnished by live steam or exhaust steam it is safe to assume that the transmission loss in the conduit will be about 15 per cent. and this leaves 85 per cent. of the total available heat which may be counted upon as producing heating effect in the radiating surface.

Radiating Surface per Pound of Steam

On the assumption that a room temperature of 70 deg. F. is to be maintained in zero weather, and that each square foot of radiating surface will radiate 1.7 B.t.u. per sq.ft. per deg. difference in temperature between the air and the steam for an average steam pressure of, say 5-lb. gage, about 267 B.t.u. per hr. per sq.ft. of radiating surface will be radiated, so that if the total radiating surface be multiplied by 267, the product will be the number of heat units to be supplied per hour. The inverse calculation shows that, allowing 15 per cent. heat loss in the conduit, exhaust steam at 5-lb. gage pressure which contains, say 900 B.t.u. per lb., will supply.

$$900 \div (267 \times 0.85) = 4 \; sq.ft.$$

A similar calculation can easily be made for live steam by using the total heat available in place of the figure 900. It is evident that the amount of radiating surface supplied by the high-pressure steam is not greatly in excess of that supplied from exhaust steam, and if the steam supply necessary is estimated conservatively the figure of 4 sq.ft. of radiating surface per pound of steam per hour will not be far wrong.

Steam Pipe Sizes

The size of steam pipe for supplying a given quantity of steam under given conditions may be obtained by reference to the charts given in the article by H. V. Carpenter, Power, Dec. 17, 1912.

Knowing the square feet of radiation, an approximate rule for determining the diameter of main in inches to supply it is:

Divide the square feet of radiation by 100 and extract the square root of the quotient.

The rule is based on a velocity of 10 ft. per sec. in the main. For other velocities reference may be made to Table 1.

Hot Water Systems

In this system actual heating of the water may take place in exhaust-steam heaters, live-steam heaters, heating boilers, economizers and condensers. One of the most economical sources of heat is, of course, that of the exhaust steam from engines and other steam-consuming machines. The amount of this heat is as before shown about 85 per cent. of the total heat of the steam entering the engine and it is obvious that most economical operation from the standpoint of the engine is brought about when its exhaust steam is condensed by giving up its heat to the circulating water. The amount of vacuum produced is limited by the amount of heating water circulated and also by its temperature. If it is desired to circulate the water at a temperature of, say 180 deg. F., it is apparent from the steam table that at this temperature a vacuum of 14.4 in. of mercury can be carried. This will increase the economical performance of the engine considerably.

It is evident that a large amount of water must be circulated at this temperature, to condense the steam, especially as the circulating water is rarely cooled through a greater range than 20 deg. Since the latent heat of steam at this pressure is 990 B.t.u., there must roughly be circulated about 50 lb. of water per pound of steam, or an equivalent of slightly over 6 gal. of water per pound of steam.

It then becomes necessary to ascertain whether the total amount of water necessary to condense the exhaust steam can be cooled through the temperature range by circulating it through the radiating system. If it is assumed that each pound of water is raised in temperature 25 deg. F. in passing through the exhaust-steam heaters, the pounds of water that may be heated by one pound of exhaust steam will be the total heat available per pound of exhaust steam divided by 25, and if it is assumed that under average conditions the total heat available will be 850 B.t.u. per hr. per lb. of exhaust steam, then the number of pounds of water heated per pound of steam will be

$$850 \div 25 = 34$$

If it is assumed that the temperature drop of the water passing through the radiators is 20 deg., then this 34 lb. of water will give up

$$34 \times 20 = 680 \; B.t.u.$$

If the room temperature is 70 deg. and the water is cooled from 180 to 160 deg. F. (an average temperature of 170 deg.), then the difference in temperature will be

$$170 - 70 = 100 \; deg.$$

so that each square foot of radiating surface will radiate

$$100 \times 1.7 = 170 \; B.t.u.$$

The number of square feet of radiating surface which will be supplied by the heat given up by the water will therefore be

$$680 \div 170 = 4 \; sq.ft.$$

This means that under the conditions stated one pound of exhaust steam having a total available heat of 850 B.t.u. will supply 4 sq.ft. of radiating surface.

Assuming the same drop in temperature and an average water temperature through the radiation of 170 deg., then one gallon will weigh 8.13 lb. and will give up

$$8.13 \times 20 = 162.6 \; B.t.u. \; per \; gal.$$

With a difference in temperature between the room and the water of 100 deg. and a rate of transmission of 1.7 B.t.u., each square foot of radiating surface will radiate 170 B.t.u. per hr. It is evident then that under these conditions, which are average ones, one gallon of water per hour will supply approximately one square foot of radiating surface. The amount of water required under other conditions is shown in Table 2.

Live steam is only used where it is necessary to aug-

TABLE 1. SIZES OF STEAM MAINS FOR DIRECT RADIATION*

Drop of Pressure, 100-ft. run. (Unwin Formula). Condensation 0.3 lb. per sq.ft. per hr.

Velocity ft. per sec.	10 ft. Vel.		20 ft. Vel.		30 ft. Vel		40 ft Vel.		50 ft. Vel		70 ft Vel.		100 ft. Vel.		100 ft. Run 1 oz. drop.	
Size of Main, In.	oz. Drop	Sq.ft. Rad'n	oz. Drop	Sq.ft. Rad'n	oz. Drop	Sq.ft. Rad'n	oz. Drop	Sq.ft. Rad'n	oz. Drop	Sq.ft. Rad'n	oz. Drop	Sq.ft. Rad'n	oz Drop	Sq.ft. Rad'n	Vel.	Sq.ft. Rad'n
1	0 4	25	1 6	49	3 6	74	6 00	100	10 00	124	19 6	174	40 00	248	15 8	40
1¼	0 29	39	1 16	77	2 61	116	6 64	155	7 25	194	14 21	271	29 00	388	18 5	75
1½	0 2	56	0 8	112	1 80	168	3 20	224	5 00	280	9 8	392	20 00	560	22 5	126
2	..	..	0 48	200	1 08	300	1 92	400	3 00	500	5 88	700	12 00	1,000	29 0	286
2½	..	..	..	..	0 75	465	1 34	620	2 10	775	4 1	1,085	8 40	1,550	34 5	535
3	..	..	..	..	0 56	669	1 00	892	1 56	1,115	3 06	1,561	6 25	2,230	40 0	890
3½	..	..	..	..	..	..	0 85	1,216	1 33	1,520	2 6	2,128	5 31	3,040	43 4	1,360
4	..	..	..	..	..	..	0 66	1,600	1 04	2,000	2 04	2,800	4 16	4,000	49 0	1,950
4½	..	..	..	..	..	..	0 53	2,005	0 83	2,506	1 63	3,508	3 33	5,012	54 8	2,747
5	..	..	..	..	..	..	0 48	2,480	0 75	3,100	1 37	4,340	3 00	6,200	58 0	3,600
6	..	..	..	..	..	..	..	..	0 57	4,470	1 12	6,258	2 30	8,940	66 0	5,900
7	..	..	..	..	..	..	..	..	0 45	6,083	0 887	8,516	1 81	12,167	74 3	9,040
8	..	..	..	..	..	..	..	..	..	..	0 76	11,130	1 56	15,900	80 0	12,700
9	..	..	..	..	..	..	..	..	..	..	0 637	14,095	1 30	20,137	87 4	17,600
10	..	..	..	..	..	..	..	..	..	..	0 57	17,360	1 18	24,800	92 0	22,900
12	..	..	..	..	..	..	..	..	..	..	..	..	0 94	35,800	103 0	37,000
14	..	..	..	..	..	..	..	..	..	..	..	..	0 78	48,700	113 0	55,300
16	..	..	..	..	..	..	..	..	..	..	..	..	0 66	63,600	123 0	78,300

* Condensed from "Steam Circulation" Positive Differential System Co.

TABLE 2. WATER REQUIRED PER HOUR PER SQUARE FOOT OF RADIATING SURFACE

Temp. of water, deg. F	140	150	160	170	180	190	200	210
Wt. per cu.ft.	61.37	61.18	60.90	60.77	60.55	60.32	60.07	59.82
Temp. of rm., deg. F	70	70	70	70	70	70	70	70
Dif. bet. temp. water and air in room	70	80	90	100	110	120	130	140
B.t.u. emitted per hr. per sq. ft. of radiator per deg. diff.	1.4	1.45	1.45	1.5	1.5	1.5	1.6	1.6
Total B.t.u. per sq.ft. per hr. (Item 4x Item 5)	98	116	130	150	165	180	208	224
Lb. water to each sq.ft. per hr. if cooled 5 deg. pass'g through radiator.	19.6	23.2	26.0	30.0	33.0	36.0	41.6	44.0
Lb. when cooled 10 deg. in passing	9.8	11.6	13.0	15.0	16.5	18.0	20.8	22.0
Lb. when cooled 15 deg. in passing	6.5	7.7	8.6	10.0	11.0	12.0	13.8	14.9
Lb. when cooled 20 deg. in passing	4.9	5.8	6.5	7.5	8.25	9.0	10.4	11.2

ment the supply of exhaust steam and furnish the radiation under contract. This may be delivered through the same set of piping to the heaters as is the exhaust steam by delivering it through a reducing valve, or it may be delivered direct to live-steam heaters which are operated either in series or in parallel with the exhaust heaters. Where exhaust steam is used to heat circulating water, it is usual to deliver it through an oil separator before passing to the heaters, and the condensation from the heaters is used as boiler-feed water.

Circulating Pumps

Both reciprocating and centrifugal pumps are used, but the latter is preferred. It may be either motor driven or connected direct to a steam turbine. The latter is the more economical arrangement when the exhaust from the turbine can be utilized in heating the water. In any system it is usually the practice to install at least two pumps, one of which may carry the entire load and the other be a spare unit. In larger systems sometimes as many as four pumps are installed to operate in parallel and their size is such that a single pump may be out of service and the others still have the capacity to circulate the entire amount of water necessary.

Sizes of Mains

The allowable velocity of water in the flow mains may be as high as 10 ft. per sec. The diameter of the pipe for carrying any amount of water may be easily calculated when the velocity is assumed, but if the piping system is of considerable extent and somewhat complex, it is better to calculate as closely as possible the friction head which will exist under any assumed velocity and if it appears to be excessive, the size of the pipes may be increased sufficiently to reduce this velocity. In any case the problem is one of balancing the cost of the increased power necessary to circulate the water at the higher resistance against the interest cost of the greater investment in larger size pipe.

The flow capacity of pipes of various sizes and for various water velocities up to 15 ft. per sec., are given in a table on page 55 of the July 9, 1912, issue of Power, and cubic feet and pounds per minute are given on page 58 of the same number.

Piping Systems

The two principal systems in use are known as the one-pipe and two-pipe systems. In the one-pipe system the water leaves the heating station through a single pipe and makes a complete circuit throughout the district, returning to the heating plant for reheating. This is sometimes known as the loop system and all radiation is connected on what are practically shunt circuits. In this case a single pipe of uniform diameter sufficient to carry the maximum quantity of water for all the services must be installed, and its diameter may be calculated on a velocity of 10 ft. per sec.

In the two-pipe system a pair of parallel pipes are run throughout the district and returned to the heating plant. Radiation is connected across these two mains in a manner analagous to connecting electrical apparatus in parallel across two circuit wires. The circulation in the two-pipe system is due to the difference in pressure between the water in the going main and the return main at the same point of the conduit. The pressure in the one-pipe system may be consequently less than for the two-pipe system, and in most cases the one-pipe system with a proper layout is preferred.

District-heating systems may be easily adapted to serve the particular heating system in use in any building or residence. For instance, in a private hot-water heating system, the hot water from the central station may be circulated through what is known as a transformer, which is essentially a water-tube heater and which becomes the source of hot-water supply for the house system. It may be adapted to warm-air systems of heating or the plenum system of heating and ventilating, by delivering the water through the indirect coils of such a system. The use of the transformer with hot water, however, is necessary only in exceptional cases, but such an apparatus is more often used where the private system is a hot-water system and the heat supply from the central station is steam.

Temperature Regulation

Regulating the temperature in accordance with the weather conditions in the buildings heated, is most economically done from the power plant. Experience soon shows the necessary temperature of the circulating water to keep the room temperatures, at, say 70 deg., with any given outside temperature. Power-plant conditions can then be adjusted to maintain the necessary water temperature and also the amount being circulated, and this will be found to have a direct bearing on the amount of vacuum which can be maintained at the engines.

Pipe Sizes for Hot-Water Heating

Mr. Durand asks for criticism of his method of determining pipe sizes for forced hot-water heating systems. His table, in the Apr. 1 issue, is most useful for finding the number of square feet of radiator surface that a given pipe will supply when either the friction head or the velocity is assumed, but he does not give any basis for making either of these assumptions. He says: "A more logical method would be to fix the total friction head per 100 ft. and from the total length of the system determine the allowable friction head per 100 ft." How are we to "fix" or "determine" these things with some degree of accuracy?

Suppose we have a system in which the mains are to supply 11,000 sq.ft. of radiating surface and two branches supplying respectively 1200 and 400 sq.ft. What size of pipes should be used? The table gives the following values, any of which might be used:

Rad. Surface Sq.ft.	Size of Pipe, in.	Velocity, Ft. per Sec.	Friction Head in Ft. per 100 Ft.
11,750	5	3.30	1
11,650	4	5.15	3
11,000	3½	6.25	5
1,200	2	1.90	1
1,200	1½	3.34	4
400	1¼	1.50	1
412	1	2.68	4½

In favor of the larger sizes of pipe, with 1 ft. friction head, we have minimum cost of pumping the water. In favor of the smaller sizes we have minimum first cost of piping and covering and minimum loss by radiation from the covered mains. Will Mr. Durand be kind enough to add to his article some statement in regard to his method of selecting the best sizes of pipe for such a problem as the one here given.

William Kent.

Montclair, N. J.

EDITORIALS

Caring for Emergencies

To know what to do in emergencies and to do it quickly and without confusion is an engineer's most valuable asset. It has been said that the difference between a lawyer and an engineer is that when the lawyer gets "stuck" he may have the case delayed while he "looks up precedent" to overcome his difficulty, but the engineer must overcome the difficulty and think about it afterward.

Even though there is no time for the engineer to look up precedent when something happens in the plant, it is well for him to know or to have read of what was done in similar circumstances by other engineers. If he knows what to do the confusion and worry of emergency moments are minimized. Ignorance of what to do begets fear, and a frightened man is a mighty poor adjunct to a power plant. He usually does more damage than he sets out to rectify or prevent.

A good illustration of this was told in POWER sometime ago. The plant was noncondensing, containing three large cross-compound units, the exhaust pipes of which were connected to a common trunk line connected to an open feed-water heater. The float valve controlling the city water supply to the heater became inoperative during the night and flooded the heater and the exhaust line.

When the engineer started a unit in the morning, the water admitted to and entrapped in the low-pressure cylinder, blew out the cylinder head. Instead of investigating, he opened the throttle on the next engine and, to make a long story short, blew the cylinder heads out of all three engines.

On page 611 of this issue a contributor tells of how a duplex mine pump was kept running after the stuffing-box, gland, packing and all, had been blown out. He also describes a repair to a broken cylinder head, water end, of a pump by shrinking a ring in a groove cut in the head while the broken pieces were clamped together. These repairs were of the emergency kind and done as quickly as possible so that the service suffered no serious interruption.

We recall an engineer who had charge of a plant isolated miles from a supply house, railroad and express service. The piston of one unit broke into pieces so small as to make repairs to it impossible. The need of the engine's service was urgent, so from a piece of one and one-half-inch seasoned hardwood board a temporary piston was made by grooving the board to receive a spare set of rings which fitted the old piston. This piston gave satisfactory service until a new one arrived.

The ability to prevent avoidable accidents and keep power-plant apparatus in service under circumstances of distress, is what makes some men better engineers than others.

The way to acquire this ability is to locate the weak and vital spots in the plant and determine what will be the best thing to do should this or that piece of apparatus fail. Trace out the pipe lines and learn what valves must be opened and closed if a bad leak or break occurs in this or that line. In brief, train yourself in the operation of your plant so that you become the man to whom the other men go to when they get "stuck."

Are Your Boilers Safe?

The average engineer, when asked this question, would probably answer by stating that his boilers were regularly inspected by a competent inspector and that he never exceeded the limit of pressure allowed and, therefore, considered his boilers safe. This line of reasoning is perfectly correct as far as it goes; but do you do your part in aiding the inspector to properly diagnose your plant conditions? It is proper and right that dependence should be placed on a specialist in the matter of fixing the safe limit for pressures, but you would not think of paying a specialist to treat you for a disease without answering every one of his questions to the best of your ability and volunteering further information, that you thought might be useful to him in prescribing for you.

The maximum pressure allowable on a boiler is usually determined by a consideration of its construction and the quality and condition of its parts. There are many things to be considered, however, exterior to the boiler itself which go toward making it safe. In fact, the explosion of a sound boiler, due to an overpressure of steam, is not one of the most frequent causes of boiler accidents. In determining conditions external to the boiler itself, the man on the job can be of the greatest assistance to the inspector.

Make the inspector your confidant in all matters pertaining to the question of your plant and, by all means, tell him fully of any changes that may have occurred between his visits—whether you believe they should be apparent or not.

For example, a condition that may seriously affect the safety of your boilers, and which might easily escape the notice of the most competent inspector, is one of strain on the pipe connections produced by improper setting repairs. The setting walls, at the time of the inspector's visit, may be in first-class condition, but when repairs were made, proper attention might not have been given to the adjustment of the position of the boiler so that all strains that might have been produced on the pipe connections, due to settling, would be removed. With several boilers connected to a header, and especially if the connections between the header and the boilers are very short or direct, the engineer should make certain that no strain exists in the connections, due to a shift in position of the boilers.

If the plant is new to the man in charge, he should take the precaution to test the freedom of the piping by unbolting or loosening the connecting bolts, to see if it springs out of position. Regardless of the theories of boiler explosions, it is well established that the sud-

den breaking of a connection may produce an explosion of the boiler.

If you should be asked if the pipe connections to your boilers were under undue strain could you, from positive knowledge, answer "No?" Better try them the next time the plant is shut down. It may be you cannot force the connections together again after loosening them. Do you want to? If you cannot get repairs made in time to start Monday morning, explain the circumstances to the boss. If his office is at the plant, the chances are ten to one that he will thank you instead of growling.

Police Department to Lose Boiler Inspection Bureau?

Engineers of New York City are again wondering if the Boiler Squad of the Police Department is to be discontinued.

During the Aldermanic Investigating Committee's probing into the conduct of the Police Department, the question of the expediency of continuing in that department, the duties of boiler inspection, was raised. Subsequently the Bureau of Municipal Research investigated the work of the Boiler Squad and submitted its report to the Aldermanic Investigating Committee. The chief parts of this report are printed on page 618 of this issue.

Besides charging previous squads with grafting, the report states that some of the present inspectors were clerks, gasfitters and just ordinary patrolmen before appointment to their present positions. It is also said that one of the examiners was a lumber inspector, time keeper, etc., before assuming his present duties. Nine boiler inspectors are claimed to have to inspect an average of forty boilers a day.

Immediately following these charges the report states that the present squad under Lieutenant Van Keuren is doing better work than previous squads had done. One who did not know the "previous squads" wonders, after reading the report, if they were composed of pirates of the Spanish Main type.

After making proper investigations we conclude that the present squad is really doing as good work as it will be permitted to do. Responsible engineers in the city know that they receive a "squarer deal" from its hands than they have ever received. The taking of fifty dollars with you to insure getting your license is said to be now unnecessary.

With all due commendation to Lieutenant Van Keuren, we again emphasize the importance of taking from the Police Department the duties of the Boiler Squad. The department is no more fit, practically or technically, for the duties than is the Street Cleaning Department. But if these duties are to be transferred to the Bureau of Licenses—and that is where the Mayor wants them—and be subject more than ever to rotten political influence, let them be performed by the police Boiler Squad. It is better to have something that is getting better than something that is worse and will become still worse.

The report of the Bureau of Municipal Research recommends that the office of Commissioner of Public Safety be created, and that this office take over all engineering duties. This recommendation is commendable and we hope to see the office created.

New Jersey's State License Law

New Jersey is the latest state to fall in line with those having state laws providing for the examination and licensing of engineers and firemen. This act is printed in full on page 618 of this issue.

The engineers of New Jersey have worked for over thirty years for a law of this kind and its final enactment must be a great satisfaction to them.

Before this bill was introduced in the assembly, an enabling act was before that body, authoring municipalities to regulate engineers' examinations and licenses by their own ordinances. At the time, we pointed out editorially the weaknesses of enabling acts, showing that instead of being entering wedges, they were additional barriers to progress toward sound license legislation. We were pleased, therefore, to see the present law substituted for the enabling act.

Just as upon all previous occasions, there was strong opposition to the enactment of this law. But it finally passed both houses only to be lost, literally lost, just as though rats had eaten it, before it received the governor's signature. After the legislature had adjourned and late in the afternoon of the last day on which the governor's signing it could prevent the bill being thrown out by default, the "lost" bill was found and signed, another demonstration of the necessity of eternal vigilance in this matter.

Although nothing is said in the bill about grading engineers, it is assumed that the bureau which is empowered to draw up any necessary rules and regulations, will see to it that there will be three grades of licenses.

Despite the favorableness of the new law, we cannot refrain from expressing regret that it does not provide also for the inspection of steam boilers. New Jersey with her numerous and rapidly expanding industries needs such laws to go hand in hand with the recently enacted license law. One law or set of laws is not complete without the other. The greatest good to the public, to manufacturers and to engineers cannot be realized until both laws are jointly enforced.

We are pleased to see the enforcement of the law and the establishment of the license bureau come under the Commissioner of Labor. The work Commissioner Bryant has done in having safety devices installed in factories and in securing fire prevention legislation is good evidence that the license bureau will be well conducted. If a department of boiler inspection is created, we hope it will take over the license bureau and be placed in the Department of Labor.

"There's nothing so bad but it might be worse," is rather melancholy cheer. Nevertheless, it does us good to get our minds off from our own troubles occasionally by thinking of another's. Then when we come back to our own they do not seem quite so serious. So we hope that the verses on our foreword page may put new courage into the hearts of some of our firemen friends, who, perhaps, did not know any could be quite so unfortunate as they, until they heard of the Mallet firemen.

Does not the contemplation of such a power plant as the new Northwest Station of the Commonwealth Edison Co., described in this issue, make you proud of this day and generation and the profession with which you are connected?

READERS WITH SOMETHING TO SAY

Emergency Repair Kinks

The two emergency repairs described below were recently made to pumps in an Australian mine.

The whole stuffing-box blew out of the cover of the water cylinder of a duplex pump. When the engineer reached the pump room the water was 2½ ft. deep and rising rapidly.

Two screw jacks were quickly made out of ⅝-in. round iron, pointed at one end and screwed into a long nut at the other end. The broken parts were then treated with white lead, pushed back with packing in the stuffing-box and the screw jacks then placed in position between the broken stuffing-box and the steam-cylinder cover.

This job made good until the receipt of a new cover and stuffing-box from Sydney.

A direct-acting steam pump lost the water on one side and the piston broke the cylinder head. The cylinder had a bore of 12 in. The cover was broken into three pieces, equally divided at almost 120 deg. each.

The three pieces were clamped together in a lathe chuck and a groove 6 in. in diameter was turned on its face. The broken surfaces were then painted with red lead and a mild steel ring shrunk into the groove.

This job held against a pressure of 135 lb. per sq.in. until a new cover was received.

W. Vincent Treeby.

Goodmayes, Eng.

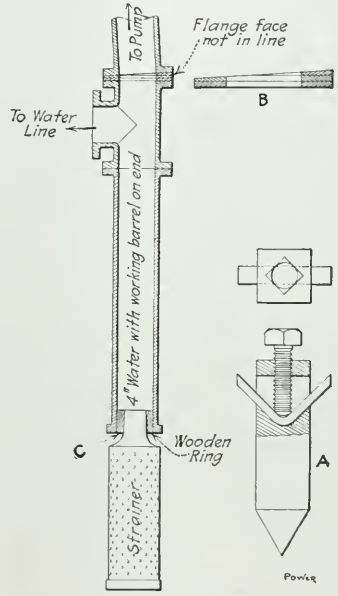
❖

Deep Well Pump Problem

How water was raised from a 6-in. driven well when the water level had dropped may be of interest. The well was 90 ft. deep and when the pump was first installed the working barrel was in 15 ft. of water. As the water delivered was continually getting less, steam and water pipes leading to the pump were disconnected and after sliding the pump aside, the sucker rods and working barrel were pulled out. By dropping a line down we found but 2 ft. of water in the well, a drop of 13 ft. in the eight years the well had been in service.

After pulling out the old strainer and lowering a new one, the sand was pumped from under it until there was 12 in. of strainer left in the casing. To make a watertight joint between the strainer and casing a wooden ring *C* was made, wedge shape to fit inside of the casing and outside of the strainer collar, which was driven tightly into the ring. As the new strainer was 15 ft. longer than the old one, there was 17 ft. of water in the well.

The working barrel was double-acting and it was necessary to use a 1-in. wrought-iron pipe instead of the old wooden sucker rods. After lowering the working barrel in place and when about to connect the pump, it was found that the flange tee connecting the pump to the water line was ½ in. out of square, as at *B*, so a gasket of several pieces of sheet rubber was made, the first piece being whole, the second one had a piece cut out and so on until it was of the right shape. After putting red and white lead between each layer of rubber the flange was bolted together; the pump delivering 50 per cent. more water than when it was first installed.



Casing of Deep Well

At *A* is shown a tool made for pulling out the old strainer, a piece of 1½-in. square iron was slotted to receive the steel jaws with a setscrew to hold them in place.

W. Chuisana.

Brooklyn, N. Y.

❖

Losses Due to Compressor Piping

In the steam plant, of which I have charge, there was installed, shortly before I came, a single-stage 8 and 10 by 8-in. steam-driven air compressor. Contrary to the advice of the engineer and the agent who sold it, the owner insisted on setting up the machine in a small room something over 100 ft. from the boiler.

The steam line was 2 in. in diameter throughout its length and, due to an oversight in installation, was connected with a 2-in. line already heavily loaded. As a result, the machine not only failed to do the work, but the cost of operating was far above what the owner had expected.

I advised moving the machine to the engine room near the boiler, or, at least, to pipe it to a separate steam line, but nothing was done and it was impossible to convince

the owner that the long steam line was the direct cause of the trouble, until I put a gage on the steam pipe at the compressor throttle, which showed scarcely 70 lb., although the boiler gage showed 100 lb. pressure.

After this, there was no longer any question about moving the machine, which was done at once. The following shows the result obtained by the change in steam and air lines: Before moving the machine it ran at 200 r.p.m. with a maximum air pressure of 20 to 40 lb. per sq.in. at a cost for coal of $55 per month. After moving the machine the revolutions were reduced to 135 per min., but the air pressure was increased to from 50 to 70, while the fuel cost per month was $29.

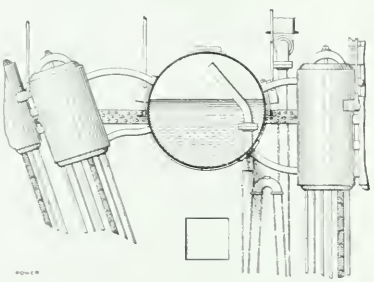
A. D. Palmer.

Roxbury, Mass.

Leaking Nipple Disables Superheater

We did not fully realize what 75 deg. superheat meant to our 3000-kw. turbine, until one day it refused to carry the overload it usually carried with a slight increase in coal consumption.

The illustration shows an end view of the steam drum, three units and the superheater of one of our boilers.



Showing Leaky Nipple Which Disabled Superheater

There are three 4-in. pipes leading from the steam drum to No. 1 superheater header. The nipple connecting one of the rear units to the steam drum leaked badly and the water sprayed on the superheater as shown. This turned the superheater into a condenser.

Thomas Sheehan.

North Adams, Mass.

An Object Lesson

Over one-half of the business places in this city were in darkness the night of Mar. 25, the Cleveland Electric Illuminating Co. being unable to supply current, because its plant was flooded. Our largest stores were compelled to close up long before their usual time and their loss in trade will amount to many thousands of dollars. This perhaps opened the eyes of some of our business men to the fact that had they plants in their own buildings they would have been able to accommodate their trade instead of turning them away and losing a large part of what such a plant would cost them.

Nearly all the light in the business section was furnished by the isolated plants, and these buildings loomed up as monuments of foresight and prudence.

O. N. Pomeroy.

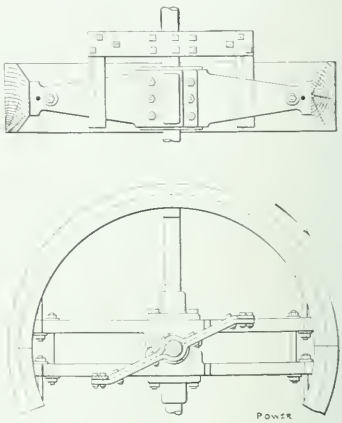
Cleveland, Ohio.

[Central stations must locate near a river or other plentiful supply of water and are thus endangered by floods. The Cleveland experience was unusual on account of the extraordinary floods.—Editor.]

Repair to a Slipping Pulley

A large split wooden pulley in our plant gave much trouble, due to slipping on the shaft.

To correct the evil a clamp, shown in the illustration, was securely fastened to the shaft next to the hub of the



Clamp with Extension Pieces to Prevent Slipping of Pulley

pulley. Two strips of hardwood were then bolted to the clamp at each end and projected into the pulley so as to each bear against the opposite sides of the pulley frame.

The arrangement works well, and the normal load is carried without fracture to the clamp.

Frederick L. Johnson.

Paterson, N. J.

Repairing a Leaky Flange

In a main supplying steam to two high-speed compound engines the flange *B*, Fig. 1, developed a leak at *C*. Due to the method of calking the steam pipe in a recess cast or turned in the flange, it became a difficult problem to stop the leak. Fig. 2 shows how the pipe was flanged over into the recess *D*. Obviously any attempt at screwing the flange along the pipe would increase the leak.

To effect a permanent repair the best way would have been to take down the length of pipe, leaving the flange *A* attached, and calk the pipe back in the recess. This method would have entailed considerable labor and time, and it would have been necessary to shut down the plant for at least two days. Rather than do this it was decided to make the repair in the following manner:

The steam main is 14 in. in diameter and carries a pressure of 250 lb. per sq.in. To effect the repair a pattern was made for a split cast-iron flange, Fig. 3, to

fit the steam main. Another pattern was made from which to cast a copper ring, Fig. 4, of suitable size to encircle the pipe. The holes in the cast-iron flange were drilled to correspond with the holes in the flange on the pipe. The copper ring was split as indicated and fitted with straps to hold the two halves together. The main flange had twenty-two ¾-in. bolts and the split flange 14 bolts, as the full number could not be inserted on account of the flanges at *EE*, Fig. 3.

When the split flange and copper ring were ready, the steam pressure was allowed to fall at an opportune time and the main stop valve was closed on the line. At the leak the surfaces of the flange and pipe were cleaned

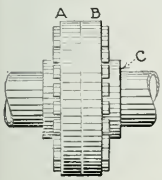


FIG. 1

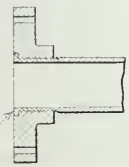


FIG. 2

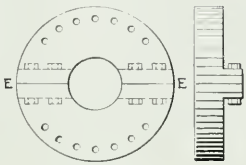


FIG. 3

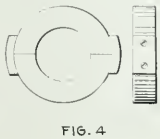


FIG. 4

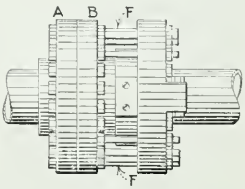


FIG. 5

and a heavy quality of tinfoil was calked into the crack. One turn or ring of heavy copper wire was placed around the pipe and against the tinfoil, the ends of the wire being soldered together. The soft copper ring shown in Fig. 4 was placed around the pipe. The split cast-iron flange was now placed on the pipe, bolted at *EE* and pulled into place by means of the long ¾-in. bolts shown at *F*, Fig. 5, which passed completely through the three flanges. Each bolt had two nuts, as shown. A permanent and satisfactory job was thus completed without shutting down the plant or incurring the expense of outside labor.

William Kavanagh.

New York City.

Radiator as Closed Heater

In many small plants the drips from steam kettles or other apparatus return to a hotwell, from which they are pumped back into the boiler at a more or less high temperature, generally less, while the exhaust from the boiler-feed pump probably blows away into the atmosphere.

A simple arrangement for improving both of these conditions is to place an old radiator in the hotwell (one with a top-feed inlet preferred) connect the exhaust pipe from the feed pump into the top feed and let the exhaust outlet be from the bottom, and opposite end of the radiator. This converts the so called hotwell into one in reality, the radiator acting as a closed heater.

James E. Noble.

Toronto, Ont., Canada.

Engine Wrecks and Remedies

How many engineers ever examine a broken piece of machinery and study it—not only how to best repair it as soon as possible, but with a view of changing the design so that the weakness will be eliminated and another break in the same place prevented? It is sometimes a good investment to substitute bronze for brass and for cast iron, and steel for cast iron.

One night the dome, attached by a nipple to a horizontal return-tubular boiler, blew off. The boiler was connected with a header and two other boilers carrying 100 lb. steam pressure. The accident occurred a short time after the engineer opened the feed-water valve to put two or three more inches of water into the boiler before firing up for the peak load.

When the dome was examined it was found that the flange had been slipped over the reduced part of the dome and that the inside of the dome nipple was peened with a hammer in but five or six places. How the boiler ran without trouble for several years with such dangerous and criminal construction is not understood. A 4-in. pipe and flange took the place of the dome, which removed the dangerous feature.

Automatic boiler-stop valves should be placed in the main outlet as close to the boiler as possible and a gate valve put in close to the header. A drain pipe should be put in the bend or the pipe between the automatic and header valves. When a boiler is cut out for cleaning, the automatic and header valves should be closed and the drain valve opened to the atmosphere so that no water can accumulate in the pipe.

After a boiler has been thoroughly cleaned and the automatic valve examined, if necessary, it should be left wide open so that when the steam is slowly raised in the boiler the automatic valve will raise the disk and allow the pipe connecting with the header to slowly warm up and trap the water back into the boiler. When the steam gage on the boiler and the battery and header register the same, the boiler should be cut in.

A bypass valve around the header valve is handy if it is desired to warm up the pipe connecting the boiler and header and equalize the pressure before opening the header valve.

In a pumping plant a pump worked against a pressure of 625 lb. per sq.in. The crank rod broke, due to the crankpin working loose in the crank disk. The design was changed and the crankpin and disk made in one piece, although it cost about twice as much as the standard crankpin and crank disk.

In another plant the 4-in. crankshaft of a high-speed, tandem-compound, 80-hp. engine crystallized and broke close to the disk. In the opinion of the writer the crankshaft should have been at least 6 in. in diameter, and a lighter flywheel used.

As to pumps, a brass or babbitt ring, making a nice fit in the oil end of a crude-oil pump will save hydraulic packing. Cast-iron snap rings in the water end of a boiler-feed pump will last many times as long as hydraulic packing, if there is considerable sand or grit in the water.

Pasadena, Calif. W. M. Glass.

QUESTIONS BEFORE THE HOUSE

Buckling of Boiler Tubes

Being particularly interested in this subject I read the letter of C. S. Davis, on page 427, and the several letters that had preceded it, hoping to get a view of the matter from some new angle. From quite a varied experience with tube troubles of this character, I find that all the correspondents on the subject have apparently correct points of view in some respects; but all of the views of none coincide with my experiences along this line.

W. A. McCooll's contention (as expressed in the July 9 issue) that differences in temperature between the inner and outer surfaces cause differences in the expansion that gradually rack the tube can hardly be assumed to be reasonable. Experiments on the transmission of heat through boiler surfaces have shown that practically all the resistance to heat transmission is experienced in getting the heat into the metal surface and from it into the water, the resistance to the transmission of the heat through the metal itself being practically negligible, particularly so for very thin surfaces, such as boiler tubes. Without appreciable resistance to the passage of the heat we can assume no considerable differences in the temperature between the inner and outer surface of the tube.

Mr. Davis' first letter, on page 313 of the Aug. 27 issue, is evidently considerably in error. In the first place, as pointed out by the editor, it is possible to overheat a clean tube under certain conditions, that is, a tube that would be considered clean for boiler operation. If a tube had a polished surface in contact with the water, it would be much more difficult to overheat it. Mr. Davis' statement that the tubes of water-tube boilers always bow upward when overheated by scale deposits is not borne out by my experience, which has been that the tubes on the lower rows of vertically baffled boilers, such as the B. & W. type, are likely to bow in almost any direction, with possibly a slight preference toward sagging. In horizontally baffled boilers, such as those of the Heine type, the decided preference is toward upward bowing, notwithstanding the fact that, to bow in this manner, the weight of the tile baffles, as well as that of the tubes themselves, must be raised.

The common theory is that a tube will be bowed convexed on the hot side and to explain the eccentricity of the bowing of the tubes in the horizontally baffled boilers, it is usually assumed to be caused by the overheating of the upper part of the tube produced by its contact with the hot baffle tile, when the boiler is emptied too soon after shutting down. This theory has failed to appeal to me, because I have known instances of such distortion where it was certain that no such careless methods had been pursued. The question naturally arose as to whether a tube would necessarily bow convexed on the heated side; and an experiment with a gasoline torch soon convinced me that the bending would be just the opposite if the tube was heated locally in spots. The explanation for this is, that when a spot on a tube is heated, the stiffness of the structure prevents distortion to such an extent that the metal at the heated point will be upset and when the tube returns to a uniform temperature in all parts the heated side is shorter than the opposite one. If a boiler of the horizontally baffled type is fired dry the bottom tubes will sag, due to the weight of tile on them. Mr. Davis' theory regarding the presence of scale in half the tube, holding it so that it will concave on that side, is preposterous.

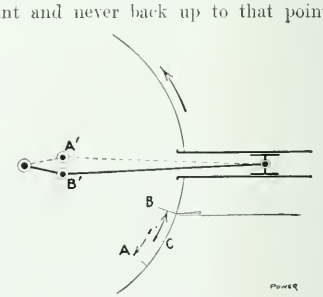
On the whole, Mr. Summer's experiences and ideas coincide with mine on this subject, except as to the bowing of the tubes in the horizontally baffled type of water-tube boilers, and here our experiences have been diametrically opposed.

J. E. TERMAN.

Hartford, Conn.

Valve Setting

In POWER's booklet, "Valve Setting," on the second page of the article, "Setting the Valve of a Slide-Valve Engine," is the following statement regarding locating the dead center of an engine: "Always turn the engine in the direction in which it is to run to bring it to a given point and never back up to that point." These



VALVE SETTING

may not be the exact words used, but they convey the same meaning.

I do not agree with this. My theory and practice is always to turn the engine in the opposite direction in establishing such points, because the pressure on the piston on the outstroke puts the connecting-rod, etc., in compression and, to have it again in compression when the engine is turned over by hand (by a force applied presumbly to the flywheel), it must be turned in the opposite direction to the normal running direction. The same facts hold for the return stroke.

Referring to the accompanying sketch, if the engine runs in the direction of the large arrow, then, to locate points *A* and *B*, the engine should be turned in the direction of the arrows at those points. *C*, the center, will be half way between.

The method just detailed will properly take care of all

back lash in connecting-rod, crosshead, etc.; but works just wrong for the back lash in the valve-gear. If the back lash in the valve-gear is greater than the back lash in the connecting-rod, etc. (which it is likely to be), the engine should be turned just opposite to the direction I previously stated.

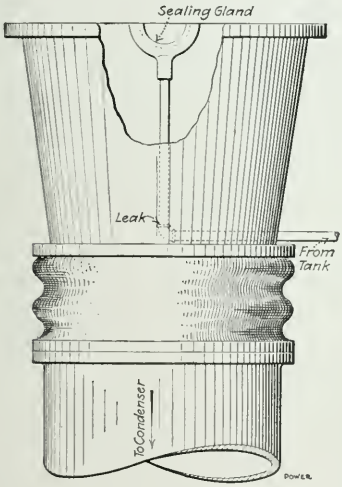
Setting a valve after all is not altogether a simple operation.

FRED E. WALCHLI.

Katispell, Mont.

Why Vacuum in Turbine Decreased

Referring to the turbo-condenser problem of Stanley C. Allen, in the issue of Jan. 7, I would state that I have experienced similar trouble with the vacuum in a turbine of the same make. This type of turbine (Parsons) has a water seal of about 5 lb. per sq.in. (sustained by the head of water from a tank elevated about 11 ft.) to prevent air leakage at the ends of the turbine shaft. In



SHOWING LEAK IN SEALING-WATER PIPE INSIDE OF TURBINE-EXHAUST END

the case I refer to the vacuum dropped to 15 in. It was discovered finally that the pipe supplying water to the seal at the exhaust end of the turbine was leaking. This pipe entered the exhaust end of the machine and continued on to the water seal, as shown in the sketch. As the leaking elbow was inside the casing it could not be seen. Perhaps Mr. Allen's turbine was likewise affected.

JOHN F. HURST.

Louisville, Ky.

Air-Receiver Explosions

I have read with great interest the letter by Letson Balliet on "Air Receiver Explosions," in the Mar. 4 issue. I have often noticed large deposits of grease and dirt in receivers, especially in the bottom of vertical receivers, and think that a large portion, if not practically all, of this deposit might be prevented from ever reaching the receiver. For instance, in using the exhaust from a reciprocating engine a separator is usually provided for removing cylinder oil, unless the steam is for some process where it does not matter. Where the steam does not come into direct contact with the process it is advisable to remove the oil or otherwise it will form a heavy deposit and prevent the passing of heat efficiently. Again, take an ammonia compressor. This is always provided with a separator to remove the lubricating oil. Would it not be worth while for one of our readers who may have the opportunity, to insert a separator between his compressor and receiver and let the other readers of POWER know the results?

So far as lubrication goes, there is not much chance of this being properly done unless the engineer will fit mechanically driven lubricators and set them himself, so that the attendant need only fill them. The supply of oil will then be controlled by the piston speed, which is the object required.

E. R. PEARCE.

Rochdale, Eng.

Guards for Flywheel Keys

Recently a reader suggested, for locking keys in place, using a filling-in piece placed behind the key and held in position by a countersunk screw. Fig. 1 shows a means I have seen for shielding keys of gas-engine flywheels.

The illustration needs little explaining, *A* being the crankshaft; *B* the boss, or hub, of the flywheel; *C* a cast-iron cap held in place by a screw *D*.

Primarily this arrangement is to protect against accidents from the key catching one's clothing, but it is also useful as a stopper or lock for the key.

At Fig. 2, is shown the same arrangement applied to

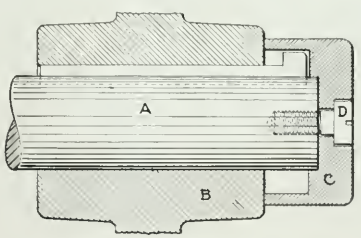


FIG. 1

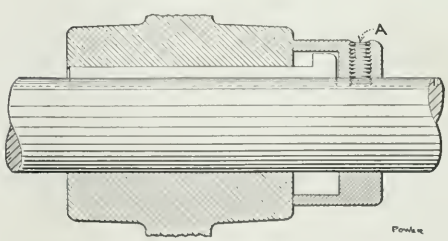


FIG. 2

GUARDS FOR FLYWHEEL KEYS

a key away from the shaft end. This is an ordinary collar recessed to pass over the key head and held in place by a setscrew *A*, which may be sunk into the keyseat slightly as a greater protection.

F. P. STRACHAN.

Belfast, Ireland.

INQUIRIES OF GENERAL INTEREST

Cloth Pinion Lubrication—How should cloth pinions be lubricated?

H. C. V.

An application of graphite once a month will keep them in good running condition.

Rivets under Shear—In a quadruple-riveted joint how many rivets are in double and how many are in a single shear?

C. O. B.

There are eight rivets in double and three in single shear.

Gas-Engine Thermal Efficiency—Do large gas engines have a higher thermal efficiency than small ones?

J. J. C.

The thermal efficiency of an internal-combustion engine is practically independent of the size. It depends on the initial compression, fuel used, thoroughness of mixture or carburization, jacket-water temperature and the general design of the combustion chamber, involving the proportion of area to volume.

Acid-Proof Ventilators—Our galvanized-iron ventilators, exposed to sulphur fumes and rain, rust through in a year. What causes it? Would copper last longer? If not, what is better?

W. C.

Moisture, taking up the sulphur fumes, forms sulphuric acid, which is destructive to galvanized or ungalvanized iron. It attacks copper almost, if not quite, as readily. Wood would be the least affected, but must be painted anyway, so that it would be just as well in the long run to use iron thoroughly painted with asphaltum, or better, P. & B. paint.

Motors Starting Under Load—Where an alternating-current motor must be started under load, what type motor should be used?

P. J. P.

A synchronous motor has a small starting torque, hence cannot be started at full load. The wound rotor, or high-resistance type of induction motor, may be started under load as it has a large starting torque, but the ordinary squirrel-cage induction motor has a comparatively small starting torque.

Good references to read in this connection are the discussion of different types of motors and their characteristics in the article by A. B. Morrison entitled "Motors and Motor Applications," printed in "Power," Feb. 25, Mar. 4 and Mar. 11, 1912, and "Signification of Torque," by Franklin Van Winkle in the Mar. 4, 1913, issue.

Sulphur in Oil—In oil fuel for Diesel engines is a high percentage of sulphur injurious?

H. McC.

Owing to the high temperature within the combustion chamber of the Diesel engine the sulphur is presumably burned completely to sulphur dioxide (SO_2) or sulphur trioxide (SO_3). Neither of these will attack the metal. Combined with water, however, they form sulphurous and sulphuric acids, respectively, which are injurious. This action is very improbable within the cylinder because of the high temperature. However, with a long exhaust pipe subject to cooling, it has been found that the exhaust gases will be sufficiently reduced in temperature for the contained moisture to condense, this condensation absorbing the SO_2 and SO_3, the acid formed attacks the exhaust pipe. Just what percentage of sulphur may be considered detrimental is largely a matter of personal opinion. Both the British and the United States Navies fix a maximum of 0.75 per cent.

Cylinder Lubricant—What grease would be best as a cylinder lubricant in place of oil? Our exhaust steam is returned to the boilers without any oil separators. Would the grease have any effect on the boilers?

M. B.

Grease for cylinder lubrication has generally been discarded since oil manufacturers have been able to furnish oils suitable for almost any requirements of steam temperature and other conditions. Greases can be furnished suitable for cylinder lubrication, but no grease will distribute itself as positively and uniformly as the proper cylinder oil. Grease also has to be fed by some type of pump and is sure to gum and carbonize in any pockets in the steam chest or cylinder. Any cylinder lubricant will be carried over in the exhaust. Grease would tend to collect in spots and be all the more likely to cause burning out of the boiler sheets. A separator would remove as much grease as oil from the exhaust steam, but even with a separator the boiler should be frequently inspected and cleaned when condensed exhaust steam is returned to it as feed water.

Water Hardness—When a water is said to be hard, what proportion of calcium carbonate or calcium sulphate does it contain?

E. J. H.

Whether water is considered hard or not depends on its intended use. For that reason hardness is generally stated in degrees and the allowable degree for any given use specified. According to Clark's standard, a degree of hardness consists of one grain of calcium carbonate, or its equivalent of another calcium or magnesium salt, in 70,000 parts of water (one English gallon of 277.274 cu.in.). Reduced to the American gallon of 231 cu.in., the standard becomes 1 grain to

$$\frac{277.274}{231} = 1.2 \text{ American gallons.}$$

For boiler use water is considered hard if it contains over 5 to 7 grains of the salts to a gallon, that is, if its hardness is more than 6 or 8 deg.

Mathematics Problems—Two questions I would like to have solved (a) A wishes to row across a river 2 miles wide to a point B exactly opposite. He can row it in ½ hr. The current moves down stream 3 mi. per hr. What direction, with reference to B must he take and how far must he row to reach B? (b) A ball rolls 40 cm. down an incline in 1 sec. The incline is 500 cm. long. One end is 40.8 cm. higher than the other. What is the value of g (the acceleration of gravity)?

F. D. S.

(a) When A rows across the river he covers a path, with respect to the moving water, that is, the hypotenuse of a triangle having an altitude of 2 miles and a base of 1½ miles (the distance the water travels in the time the man crosses the river—½ hr.). These two sides of the right triangle are in the ratio of 3:4 and of such a triangle the hypotenuse is as 5, so that it actually is 2½ mi. That is, the distance A has to row and the direction he takes with respect to B is upstream at an angle, the sine of which is $\frac{1.5}{2.5} = 0.6$, or very closely 37 deg.

(b) The acceleration parallel to the plane will be found from the formula

$$s = \tfrac{1}{2}\ pt^2$$

where

s = Distance = 40 cm.
p = Acceleration = ?
t = Time = 1 sec.

Then

$$40 = \frac{p}{2} \times 1 \qquad p = 80 \text{ cm. per sec.}$$

From this and the ratio of the height to the length of the plane, the acceleration of gravity g may be obtained from the formula

$$a = \frac{h}{l} \times g$$

where

a = Acceleration = 80 cm. per sec.
h = Height of plane = 40.8 cm.
l = Length of plane = 500 cm.

$$80 = \frac{40.8}{500} \times g$$

$$g = \frac{80 \times 500}{40.8} = 980.39 \text{ cm. per sec.}$$

ENGINEERS' STUDY COURSE

Principles of Combustion—II

Measurement of Heat

Now, before we take up combustion, coal analysis and similar subjects, we ought to get a good working idea about how heat is measured because it is necessary to measure the heat generated and absorbed so as to know what results we are getting.

Heat is measured by its intensity or degree and by its amount or quantity. If you lighted an ordinary match and held it so the flame struck the business end of a quick-acting thermometer that could stand the treatment, the thermometer would indicate a certain temperature, let us say 400 deg. Then, if you lighted two matches and held them so that both flames struck the thermometer it might astonish you when you found the thermometer showed only the same temperature as before. You could

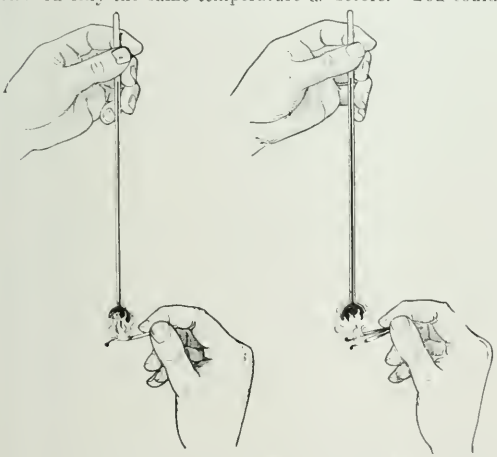


Fig. 2. Experiment to Show That a Flame's Temperature Is Independent of Its Size

easily see that there was twice as much flame and it stands to reason that there was twice as much heat because you were burning two matches instead of one and two matches have twice as much wood as one. Then, why was not the temperature twice as great? Because the temperature or the intensity of heat depends upon the nature of the fuel and the way it is burned while the amount burned determines the quantity of heat created. The fire under a 50-hp. boiler may be just as "hot," the temperature may be just as high, as the one under a 500-hp. boiler, yet it does not do as much work, that is, heat as much water, because it does not burn as much fuel and consequently does not generate as great a quantity of heat.

Now, it is seldom possible to measure the quantity of heat direct, but it is quite easy to calculate the quantity when the temperature and a few other factors are known. This is true because heat acts according to fixed laws, the same as everything else in this world. And when you once understand those laws it is easy to figure out what will happen when certain conditions prevail.

Definition of B.t.u.

The thermometer measures temperature or heat intensity and the unit of temperature is the degree. According to the Fahrenheit scale, which is the one commonly used in this country, melting ice has a temperature of 32 deg. and boiling water a temperature of 212 deg.

The unit of heat quantity commonly used is the British thermal unit or the B.t.u., as it is usually written and pronounced. It gets its name from the fact that British scientists established it or used it first and the word thermal means heat or warmth. Another way of expressing it would be, British unit of heat measurement. In fact, we often use the term heat unit when we really mean B.t.u.

One B.t.u. is the quantity of heat required to raise the temperature of one pound of water one degree.* As a gallon of water weighs $8\frac{1}{3}$ lb., it requires $8\frac{1}{3}$ B.t.u. to raise the temperature of one gallon one degree, or $16\frac{2}{3}$ B.t.u. to raise the temperature two degrees, and so on.

Thus, when a given coal is said to have a heat value of 13,800 B.t.u. per pound, it is meant that if all the heat caused by the complete combustion of one pound of that coal could be transmitted to 13,800 lb. of water it would raise the temperature of that water one degree. Or, if all the heat could be transmitted to, say 138 lb. of water, it would raise the temperature of that water just 100 deg., because

$$138 \times 100 = 13{,}800$$

The pounds of water heated multiplied by the number of degrees the temperature has been raised equals the number of B.t.u.

Indeed, the standard method of finding the heat value of a fuel is to burn a small sample of it in a tight steel bomb under water. The heat caused by the burning of the sample is then all absorbed by the water and by multiplying the weight of the water by its rise in temperature and dividing by the weight of the sample, the heat value of the coal is calculated direct in B.t.u. per pound. Thus, if we burned a small sample weighing one-five-hundredth of a pound in a bomb immersed in 5 lb. of water and if the temperature of that water increased from, say, 70.4 deg. to 75.92 deg., a rise of 5.52 deg., the heat value of the coal would be

$$\frac{5 \times 5.52}{0.002} = 13{,}800 \ B.t.u. \ per \ lb.$$

*This is only approximately true. It takes a different amount of heat to raise a pound of water from 32 deg. to 33 deg. from what it does to raise it from 100 deg. to 101 deg., or from 211 deg. to 212 deg. The B.t.u., therefore, is variously defined as the amount of heat necessary to raise a pound of water 1 deg. at its temperature of maximum density, about 39 deg.; or, at some arbitrary temperature, 60 or 62 deg., because that is assumed to be the average temperature of the surrounding air when experiments to determine the amount of heat are made; or $\frac{1}{180}$ of the amount of heat required to raise a pound of water from 32 to 212 deg. (the average amount of heat per degree). The latter definition is finding the most favor

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Have you noticed the fearful frequency (in the daily press) of the blowing out of cylinder heads of large boilers? This is an awful menace to our safety. Boiler manufacturers should be more careful how they put in these boiler cylinder heads.

⁂

A Philadelphia manufacturing concern is said to pay each man 15 cents a day extra provided he takes a bath at night before going home. Just how do you think we had better handle this item? It looms large with possibilities, but— What's the answer?

⁂

As an instance of good discipline "below decks," the daily press says that the crew of the "Cincinnati" fought fire in the coal bunkers for three days before reaching port. The first the passengers knew about it was when they landed and read it in the papers.

⁂

Here's another tale of the sea—a whaling good one, but its veracity is questioned. Capt. Tutt, of the Hamburg-American liner "Carl Schurz," is said to have reported that the ship while crossing the ocean spitted a whale. "The whale was alive and its whirling flukes sent the ship's bows to starboard." Oh, tut, tut, Tutt, and good night Schurz! You're out of order; this is the closed season for whales, and spitting is forbidden by the statoots.

⁂

American consulting engineers come high in the land of the frijole and the hot tamale. Mexican brigands want $10,000 to release one perfectly good engineer. Another had to pay $20,000 before he could resume his consultations, the Greasers having riz the tariff on him. Would be wise for engineers to include a "ransom" cost in figuring on future Mexican propositions.

⁂

A statistical fiend in Washington says "we" drink $2,000,000,000 worth of liquor, smoke $1,200,000,000 of tobacco and "absorb" $120,000,000 of soft drinks. With our constantly increasing population, possibly we need this fair amount of liquor to keep up our spirits, but what a wicked waste for soft drinks! And who is meant by 'we"? Let's have a bill of particulars.

⁂

If you were asked to give your definition of a gentleman, we bet one of those new nickels that looks like a button on little Lizzie's winter coat that you can't do better than this:

"A man that's clean inside and out; who neither looks up to the rich nor down to the poor; who can lose without squealing and who can win without bragging; who is considerate of women, children and old people; who is too brave to lie, too generous to cheat, and who takes his share of the world and lets other people have theirs."

And this standard works out as well for the overalls as for the joyous habiliments of swell society.

⁂

Engineer Hill, of the Middletown pumping station, deserves great praise for sticking to his post for forty hours during the recent flood, but he must regret that the daily press got a hack at the story. It has Jules Verne's "Twenty Thousand Leagues under the Sea" permanently submerged. His station—and Hill in it—disappeared "below the raging water." But dip in and help yourself!

"They could not find the roof of the structure, and the hearts of the men were heavy. Finally Friday morning the peak of the roof of the station appeared above the water and in an hour or so the waters were down sufficiently to cut a hole in the roof. To the astonishment of the rescuers, Hill was found safe and sound, still able to feed the engine with fuel, and though somewhat haggard and ghastly looking from lack of pure air and weak from thirst and hunger, he was in splendid condition after a few square meals. There was no difficulty in getting his first meal, and the cheers that greeted the announcement of the safety of the engineer repaid him for the hair-raising experience of hearing the swish of the waters around, over and almost under him for forty hours."

The reporter failed to say if Mr. Hill got wet or that closing the windows may have saved him.

New York Police Department to Lose Boiler-Inspection and Engineers' License Bureau?

During the Aldermanic Investigating Committee's probing into the conduct of the New York Police Department, the point was raised as to the advisability of continuing under that department, the duties of boiler inspection and examination and licensing of engineers and firemen.

The Bureau of Municipal Research subsequently reported on the condition of this branch of the police department.

The bureau cannot comprehend why the inspection of boilers should be performed by the police department. The report then goes on to show why the department is unfit, practically and theoretically, for performing such duties. Charges of graft are made against inspectors, although the report admits that the present squad under Lieut. Van Keuren is far superior to previous squads.

The training of some of the present squad previous to their service as "engineers" has been as follows:

Boiler inspector, previously letter carrier, clerk and gas fitter; boiler inspector, previously fireman and oiler; boiler inspector, previously patrolman; examiner, previously clerk, lumber inspector and time keeper.

It is stated, also, that there are only nine boiler inspectors and these must inspect on an average of 40 boilers a day.

The bureau recommends the creation of a Commissioner of Public Safety, appointed by and subservient to the Board of Estimate and Apportionment, and that all engineering duties be removed from the police department and assumed by this commissioner whose salary is recommended at from $10,000 to $12,000 a year.

The report embodies several suggestions as to inspection of boilers, specifications as to the use, installation and location of various forms of refrigeration machines. More rigid inspection of elevators is recommended. There are some parts of the suggestions relative to the grading of engineers and the kinds of plants which they may operate, that are objectionable, but as they are only suggestions, they are of little importance.

Editorial reference is made to this report on page 610 of this issue.

⁂

New Jersey State License Law

The act printed in full below, to which editorial reference is made on page 610, was signed and became a law, at the closing hours of the April special sessions of the New Jersey Legislature.

SENATE COMMITTEE SUBSTITUTION FOR ASSEMBLY BILL NO. 338, STATE OF NEW JERSEY, MARCH 25, 1913

AN ACT to provide for the examination and license of engineers and firemen having charge of stationary and portable steam boilers and steam engines, and to prohibit the use of such steam boilers and steam engines unless the person in charge thereof shall be licensed.

BE IT ENACTED by the Senate and General Assembly of the State of New Jersey:

Sec. 1. Within sixty days after this act shall take effect the Commissioner of Labor of the State of New Jersey shall establish in the Department of Labor a bureau to be known as the Steam Engine and Boiler Operators' License Bureau, to consist of three persons, citizens of the State of New Jersey, each of whom shall have been engaged for at least ten years in the occupation either as engineer in charge of a steam plant of not less than two hundred and fifty horsepower, or as the inspector for a steam engine and boiler insurance company licensed to do business within the said State, and who shall also be approved by the Civil Service Commission of this State. Each of the said persons constituting said bureau shall hold office for three years, their term of office expiring on the first day of May, excepting, however, those first appointed, one of whom shall be appointed until the first day of May, then ensuing; another until the first day of the May succeeding the term of the one first appointed; another until the first day of the May succeeding the term of the second one appointed, in order that the term of office of one of those appointed may expire on the first day of May of each year. Any vacancy occurring in the membership of the said bureau shall be filled by the Commissioner of Labor from persons properly qualified as aforesaid for the unexpired term.

Sec. 2. Each person appointed a member of said bureau shall, before entering upon the discharge of his duties and within thirty days after he has been appointed, take and subscribe to an oath before any officer authorized to administer oaths in this State, for the faithful performance of his duty,

which shall be filed with the said Commissioner of Labor and transmitted by him to the Secretary of State. They shall from time to time select one of their number for chairman. They may adopt all necessary rules, regulations and by-laws for their government not inconsistent with the laws of this State or of the United States, and shall prescribe rules for the examination and licensing of engineers and firemen in charge of stationary and portable steam boilers and steam engines within the State, and to prevent the use of such steam boilers and steam engines unless the person in charge shall hold such license. Such regulations shall also specify the terms and conditions under which such license shall be issued or renewed; to fix the fees charged for the issuance and renewal of such license; to provide for the revoking, for proper cause, of any license issued, all of which shall be subject to approval of the said commissioner and any of which may be revoked or annulled at any time by him. They shall report from time to time to the commissioner and in such form as he shall prescribe. All licenses recommended by them shall be issued under the hand and seal of the commissioner and a record thereof kept in his office.

Sec. 3. The provisions of this act shall not be construed to include or apply to any person in charge of or operating a steam boiler or steam engine under the control of the government of the United States, or any steam boiler used in railroad locomotives, or road vehicles, or in connection with the fire department of any municipality or public body of this State, or any steam boiler used exclusively for heating purposes, which boiler does not carry a pressure of more than ten pounds per square inch, nor shall it apply to any person holding a United States Marine License.

Sec. 4. Within sixty days after said bureau shall have been organized no person subject to the provisions of this act shall operate any steam boiler or steam engine without having a license herein provided for, except in case of emergency, and then for no longer than thirty days, of which emergency the owner of such steam boiler or steam engine, or the agent, superintendent or manager in charge thereof shall promptly notify such bureau in writing, stating briefly the circumstances in connection with such emergency.

Sec. 5. Application for license shall be made on blanks to be provided for that purpose by the bureau and shall state clearly the name, residence, age, color and nationality of the applicant, whether or not he is a citizen of the United States, and his previous experience as engineer or fireman.

Sec. 6. The fee for such examination and license shall be at the rate fixed by the said commissioner, not more than two dollars. Any license so issued may be revoked by the commissioner for ignorance, neglect or intoxication upon duty, after notice to the holder thereof and a hearing afforded him before the said bureau. In case such revocation be recommended by said bureu, it shall not be acted upon by said commissioner until at least five days' notice of such recommendation shall be given the person holding such license and an opportunity afforded him to ask for a rehearing before the commissioner. After such rehearing, if allowed, the commissioner may either comply with or dismiss such recommendation, or in a proper case, may suspend for a limited time such license.

Sec. 7. No engineer or fireman actually in charge of any steam boiler engine at the time this act takes effect, shall be required to take the examination required by this act, but shall receive a license as such engineer or fireman from the said commissioner upon the written request of the owner of the boiler or engine upon which he is engaged or by the agent, superintendent or manager of such owner, which application shall be made, however, within the time herein fixed for such examination.

Sec. 8. The form of license so as aforesaid to be issued shall be in such manner as the Commissioner of Labor shall approve.

Sec. 9. Each member of the bureau shall be entitled to have and receive as and for his compensation the sum of twelve hundred dollars per year, payable monthly, in the same manner as the compensation of other employees of the said Department of Labor. The fees received by the commissioner for such licenses shall be paid into the State Treasury.

Sec. 10. Any person so appointed a member of the said bureau may be removed by the said commissioner for sufficient cause the same as any other person in the Department of Labor appointed by him.

⁂

The demand for anthracite coal fell off in the shipments during March, which were 1,660,399 tons less than those of March, 1912. In March, 1912, the shipments were 6,569,687 tons; in March, 1913, 4,909,288. The coal at shipping ports was 484,270 tons on Feb. 28, and 772,115 at the close of March, an increase of 287,845 tons.

Towne Scientific School Students' Trip

The first annual inspection trip of the senior students of the Towne Scientific School, University of Pennsylvania, was made during the Easter recess, Mar. 20 to 29, under the leadership of Prof. R. H. Fernald, the new head of the mechanical engineering department. The trip included Pittsburgh, Cleveland, Toledo, Niagara Falls, Schenectady and New York City.

Two days were spent at Pittsburgh and vicinity in visiting the plants of the Westinghouse Machine Co., the Westinghouse Electric & Manufacturing Co., the Jones & Laughlin Steel Co., the National Tube Co., at McKeesport, and the large mine of the Pittsburgh-Buffalo Co., at Marianna, Penn.

In Cleveland the new Lake Shore station of the Cleveland Electric Illuminating Co. and the city pumping station at Kirtland St. were inspected. The Peerless Motor Car Co. entertained the party by a sight-seeing trip through the suburbs and after its plant at East Ninety-third St. was inspected, the company acted as host at a luncheon to the students. The stay at Cleveland was concluded by a trip through the plant of the National Carbon Co.

At Toledo the attractions were the gas-engine driven filtration plant on the Maumee River and the Edward Ford Plate Glass Co.

The Niagara Falls Power Co. plants, Nos. 1 and 2, the International Paper Co., the Shredded Wheat Biscuit Co., and the Ontario Power Co. were visited at Niagara Falls. Owing to delays on the road because of floods, the trip through the General Electric Works at Schenectady had to be made very hurriedly in order to get to New York City.

The first day in New York was spent in the Waterside plants of the New York Edison Co. and the Fifty-ninth St. Station of the Interborough Rapid Transit Co. The trip ended with a visit to the Singer Building, the Pennsylvania R.R. Terminal and the Hotel Astor.

Though hampered considerably by floods, the trip was considered such a complete success that it is expected it will be made compulsory in the course of another year or two.

⁂

Mechanical Engineers Meet at New Haven

On the afternoon and evening of Apr. 16, the local branch of the American Society of Mechanical Engineers at New Haven met at the Mason laboratory of the Sheffield Scientific School. These meetings have been held twice a year, and as usual there was a good attendance.

In the afternoon the subject was "Factory Heating and Ventilation." A. C. Staley, of the mechanical engineering department, presented the introductory paper, which was an elementary lantern-slide treatment of types of system and apparatus. Starting with the ordinary stove and hot-air furnace, the discussion led up to direct heating by steam and hot water. The different arrangements of piping and the apparatus employed were shown, and the same was done with hot-blast and indirect heating, with some attention to cleaning the air and obtaining the proper humidity.

G. H. Miller, of Cheney Bros., South Manchester, followed with a description of the system covering the company's various mills. Different systems using steam at different pressures had formerly been employed in the various buildings. The entire system has now been unified and all buildings receive steam reduced from 125 to 5 lb. pressure from a common source. A vacuum pump is located in each building rather than at the central plant. The longest run is about 1300 ft., and with a 10-in vacuum at the pump the operation of the system as a whole has been satisfactory. In some of the buildings direct radiation is used and in others, hot-blast heating, with provision for cleaning and adding moisture to the air.

W. G. Snow talked Webster vacuum and pressure systems with particular reference to the Modulation and Sylphon valves.

James A. Donnelly outlined the method of testing radiator valves recently adopted by the New York chapter of the American Society of Heating and Ventilating Engineers.

Other speakers were W. F. Goodnow, on Vento radiation, Mr. Pryor, of the Carrier Co., on air washing, and W. J. Baldwin on the proper temperature and humidity which should be maintained in a room.

Intermission gave an opportunity to view a special exhibit of gas arc and other types of gas lamps and, of course, the general equipment of the laboratory.

Clarence E. Clewell, instructor in electrical engineering, introduced the subject of the evening with a paper on "Factory Lighting." Some interesting discussion closed a very successful meeting.

Heating Engineers to Meet at Indianapolis

The fifth annual convention of the National District Heating Association will be held in Indianapolis, Ind., on Tuesday, Wednesday and Thursday, May 27, 28 and 29, 1913. The headquarters of the convention will be the Claypool Hotel, where the sessions will be held, and in the convention room space will be reserved for the exhibits. Besides the various reports of committees, the following papers have been outlined: "Hot-Water Heating for Residence Districts," A. C. Rogers; "Possibilities of Hot-Water Heating," N. M. Argabrite; "District Heating on the Pacific Coast," Charles F. Murphy; "Discussion on the Use of Bleeder Turbines," by the users; "Commission Control of Utilities," D. L. Gaskill; "Appraisal of Heating Properties," Harold Almert; "Station Designs with Special Reference to Overload Capacities," Mr. Denman; "Is District Heating Profitable to the Central Station?" C. J. Davidson: "Operating Economics in Heating Large Factory Buildings," Edward L. Wilder.

New Jersey N. A. S. E. State Convention

The convention committee of the New Jersey State N. A. S. E. for the coming state convention in Newark, May 22 to 25, reports unusually good results in the sale of booths; 83 out 132 having been sold up to Apr. 16.

This year's convention promises to be even more successful than those of former years, and the committee is making preparations for caring for unusually large crowds. The convention hall will be found very convenient for exhibitors, and as the floor level is only 18 in. above the street, the moving of heavy machinery will be simple and inexpensive.

SOCIETY NOTES

The annual meeting of the Iron and Steel Institute will be held at the Institution of Mechanical Engineers, at London, on May 1 and 2. During the second day's session the Andrew Carnegie gold medal (for 1912) will be presented to J. Newton Friend, Ph. D., and the awards of research scholarships for the current year will be announced. Some fourteen papers are expected to be read and discussed. The autumn meeting will be held at Brussels, Sept. 1 to 5.

It is announced that the thirteenth annual six weeks summer school of the College of Engineering of the University of Wisconsin will open on June 23. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shopwork and surveying, in addition to which subjects may be taken in the College of Letters and Science. For a bulletin, address F. E. Turneaure, University of Wisconsin, Madison, Wis.

The April meeting of the Massachusetts Chapter of the American Society of Heating and Ventilating Engineers at Boston, was devoted to a general discussion of breaks in radiators. It was found that certain designs of the wall type of cast-iron radiator were known to break, after installation, caused by the strain not being properly taken care of or equalized in the design. The method of installing and hanging was also taken up and several specific cases were explained, but it was the opinion of the engineers that this trouble was chiefly due to the faulty design of the radiator. A general discussion of air conditioning at the Museum of Fine Arts followed, Mr. MacLean, its superintendent, explaining at length the installation, the effect and general benefits.

PERSONALS

T. T. Burchfield has assumed the Philadelphia agency of A. L. Ide & Sons, Springfield, Ill.

W. E. Wolmagott, city electrician of Peoria, Ill., has been elected president of the Peoria Electrical Club.

James D. Andrew has resigned from the Boston Elevated Ry. Co. to become superintendent of power stations for the Boston Edison Co.

I. E. Moultrop, formerly mechanical engineer of the Boston Edison Co., has been promoted to the position of assistant superintendent of construction.

W. H. Tees, formerly chief electrician of the Canadian Consolidated Rubber Co., Montreal, Que., and is now assistant superintendent of the Sayer Electric Co., of Montreal.

Elmer Iverslin has succeeded P. B. Renther as chief engineer of the municipal electric-lighting plant at Belgrade, Minn., and will also act as manager and superintendent.

Eugene L. Barnes has taken charge as district manager of the newly opened Pacific Coast offices of the American District Steam Co., North Tonawanda, N. Y., in the Hoge Bldg., Seattle, Wash.

Harry B. Aller, who for two years was out of the steam specialty field, is now representing the Ashton Valve Co. in Illinois, Wisconsin, Minnesota and Missouri. Mr Aller will make Chicago his headquarters.

Clark, MacMullen & Riley, Inc., consulting engineers for the design of heating, ventilating and electrical equipments, formerly at 80 Maiden Lane, now have their offices in the Architects' Building, 101 Park Ave., New York City.

Prof. Henry H. Norris, of the department of electrical engineering, Cornell University, and secretary of the Society for the Promotion of Engineering Education, is devoting a leave of absence to a special investigation of engineering books in all fields for the McGraw-Hill Book Co., New York. His work will cover both college textbooks and general technical reference books.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared by the Fall River Electric Co., Fall River, Mass., for an expenditure of $200,000, for extensions and equipment for its plant. A. H. Kimball, Fall River, is general manager and purchasing agent.

The Corning Light & Power Co., which recently acquired the property of the Corning Gas & Electric Co., will construct a new power plant at Corning, N. Y.

The Commonwealth Water & Light Co. will expend $20,000 for extensions and improvements to the power plant of its subsidiary company at Lakewood, N. J.

Plans have been prepared for the construction of a power plant on 19th St. and Allegheny Ave., Philadelphia, Penn., for the Storage Battery Co.

SOUTHERN STATES

An election will be held on May 6 to vote on the proposition to issue $25,000 in bonds for the installation of a waterworks system at Cherryville, N. C.

The proposition to issue $20,000 in bonds for the construction of a municipal electric-light plant at Washington, N. C., is under consideration.

Bonds for $8000 have been voted for the construction of a municipal electric-light plant at Abbeville, Ga.

Plans are being prepared for the improvement and extension of the municipal electric-light plant at Quitman, Ga.

It is proposed to issue $20,000 in bonds for the improvement of the municipal electric-light plant at Roanoke, Ala.

The city council of Estherwood, La., is considering the proposition to construct a municipal electric-light plant.

Plans are being prepared by Henry A. Mentz, Randolph Bldg., Memphis, Tenn., for the construction of a municipal water-works system at Dresden, Tenn. Estimated cost, $15,000.

The city council of Henderson, Tenn., has been authorized to issue $50,000 in bonds for the construction of a municipal electric-light plant and water system.

CENTRAL STATES

Plans are being considered by the Factory Power Building, Oakley, Cincinnati post-office, Ohio, for the construction of an addition to its power plant, for the purpose of supplying 500-hp. in addition to the energy now produced. Zettel & Rapp are architects.

Bids will be received by the board of trustees of public affairs of Paulding, Ohio, until Apr. 29, for the installation of new equipment in the municipal electric-light and water plant. J. F. Morrissey is president of the board.

Bids will be received by J. W. Sanderson, treasurer of the Marin Branch of the National Home for Disabled Volunteer Soldiers, until May 2, for the installation of new equipment and the improvement of the power plant at National Military Home, Ind.

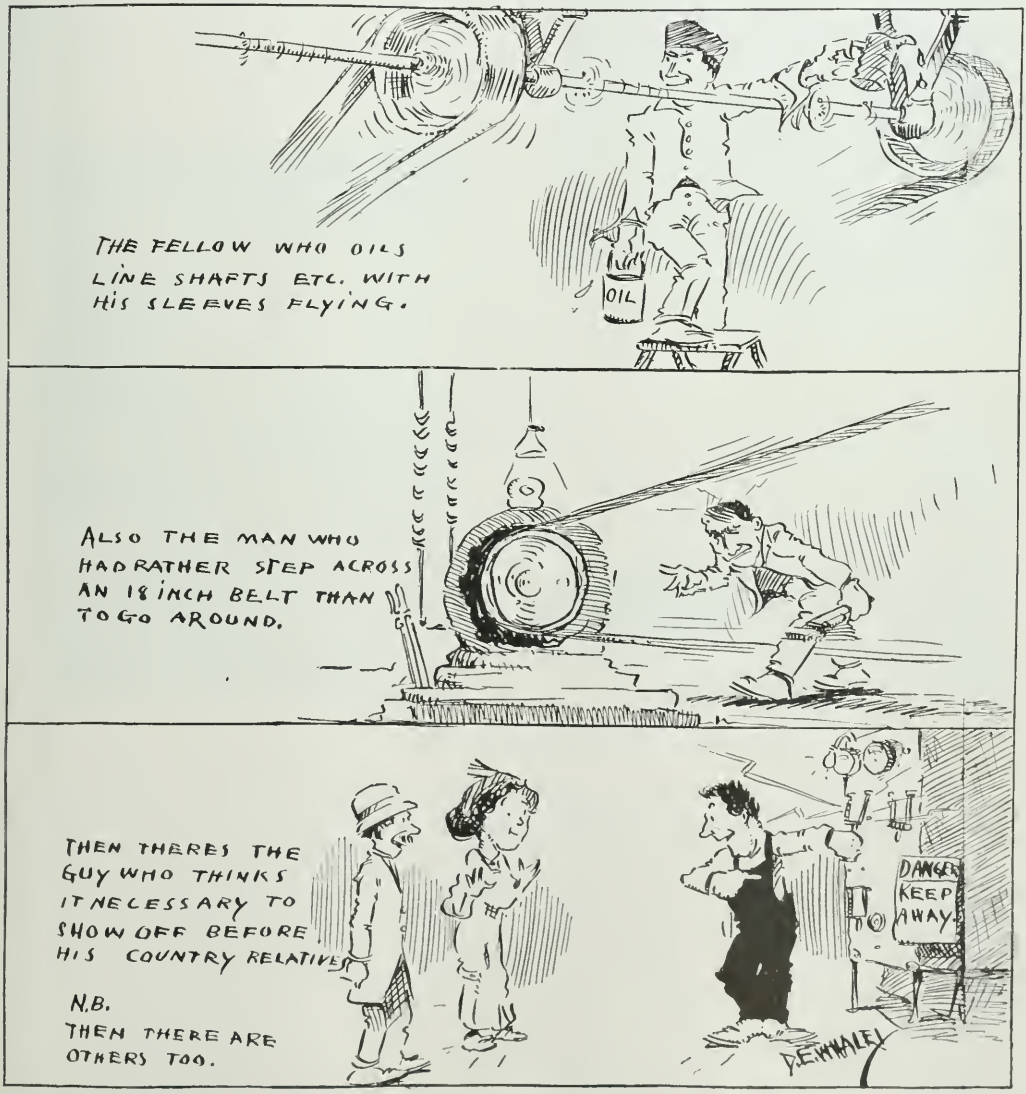
The proposition to construct a municipal electric-light plant at Alton, Ill., is under consideration. J. F. Schwaab is city engineer.

The Piasa Light & Power Co. will construct a substation at Alton, Ill. Roy Holden is manager.

Plans are being considered by the village authorities of Deer Park, Wis., for the construction of an electric-light plant.

POWER

Vol. 37 NEW YORK, MAY 6, 1913 No. 18


THE FELLOW WHO OILS LINE SHAFTS ETC. WITH HIS SLEEVES FLYING.
OIL
ALSO THE MAN WHO HAD RATHER STEP ACROSS AN 18 INCH BELT THAN TO GO AROUND.
THEN THERES THE GUY WHO THINKS IT NECESSARY TO SHOW OFF BEFORE HIS COUNTRY RELATIVES
N.B. THEN THERE ARE OTHERS TOO.
DANGER KEEP AWAY
P.E. HALEY

THREE REASONS WHY SOME INSURANCE COMPANIES CONSIDER ENGINEERS A POOR RISK

Jacksonville Municipal Power Plant

By C. C. Austin

SYNOPSIS—An uptodate municipal turbine power plant of 6000-kw. capacity. Fuel oil is used in the boiler furnaces. A feature is the construction of the condenser intake water conduits which are used as a foundation for the dividing wall between the turbine and boiler rooms.

Jacksonville, Fla., boasts of one of the best equipped and most uptodate municipal power plants of its size in the United States. The old plant near the center of the city became inadequate to meet the increasing demands and could not be enlarged materially on account of the scarcity of condenser-cooling water, and also because it shared the available space with the city water plant. It was, therefore, decided to move the power plant to a site where there would be an abundance of cooling water and ground area and to leave the old site and buildings entirely to the water-pumping station.

The new plant is about four miles from the center of the city on the banks of the St. Johns River. Texas oil is used as fuel and is shipped by boat to the plant of the Gulf Refining Co., which is near the power plant; the oil is piped from there to the city tanks. If coal is ever used as fuel, it can be transported much of the distance from the mines by water. Plant supplies can also be shipped

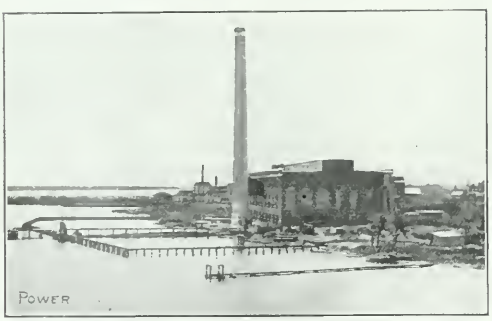


Fig. 1. General View of the Power Plant and Water Front

by water. Fig. 1 is a view of the plant. The bulkhead will be filled in and used as a storage yard for coal, if it is ever used, and as a convenient landing place.

At present the plant has a capacity of 6000 kw. and the building will admit another 1500-kw. machine. Four 1500-kw. steam-turbine units generate three-phase, 60-cycle, 6600-volt current. Special attention has been paid to securing abundant light and affording every convenience for working around the machines.

An idea of the general arrangement of the apparatus may be obtained from Fig. 3. The nature of the soil and the proximity of the St. Johns River necessitated pile foundations throughout and the intake and discharge conduits have been arranged so as to use their walls as parts of the foundations. The common center wall of the two contiguous and parallel conduits, Fig. 3, forms the foundation for the air and circulating pumps. The outside wall of the intake conduit is of double thickness to provide a foundation for the wall between the boiler and generator rooms. Instead of being side by side, the discharge conduit is mounted on top of the inlet conduit, which permits using a single row of piles to support them both. The hotwell is in the top of the discharge conduit, so built that its overflow drains into the latter.

All of the condensing apparatus is level with the boiler-room floor and below the generator floor. The open space directly above the condensers affords abundant light to inspect the operation of this machinery, except on the darkest days when it will be electrically lighted. Fig. 2 gives a view of this floor.

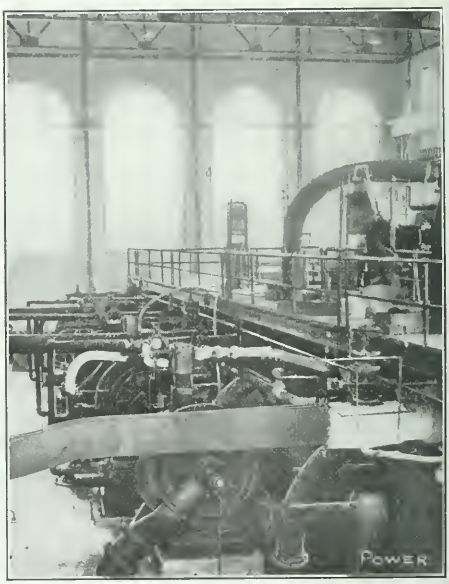


Fig. 2. Air and Circulating Pumps Serving the Condensers

A 30-ton crane of 60-ft. span, having 19 ft. in the clear under the hook, serves the generator room. This crane has a 15-hp. motor for traveling, a 30-hp. hoisting motor, and a 10-hp. motor for the trolley travel. Ten water-tube boilers are installed in batteries of two. Fig. 4 shows part of the boiler room not yet finished. Each boiler has 5200 sq.ft. of heating surface, and a superheater of 660 sq.ft. area. Steam is furnished at 175 lb. pressure and 570 deg. F. Space has been left for two additional boilers. The machine shop of the plant will be in the end of this boiler room.

A brick-lined reinforced-concrete stack, 12 ft., inside diameter, and 201 ft. high, supplies the draft. Its center is 64 ft. from the center of the breeching at the back of the boilers and it receives the gases 29 ft. above its base.

This is one of the few plants in this vicinity that uses oil for fuel. The Texas oil fields are farther from Jacksonville than the Alabama and Tennessee coal mines, but the higher calorific value of the oil, water transportation, low initial cost of burning apparatus, and low boiler-room operating costs gave it a decided preference over coal for this plant. Oil is purchased by contract and pumped to the plant. At the plant 2500 bbl. can be stored and the contract specifies that 5000 bbl. shall be kept in readiness exclusively for this plant. The oil is supplied to the boilers at 60 lb. pressure by a 6 and 5 by 4-in. duplex pump.

Steam Piping

Extra-heavy 12-in. steel piping with Van Stone joints is used in the main steam header with 8-in. piping of the same material from the boilers to the header and from the header to the turbines. Expansion joints were not used anywhere in this line, sweeping pipe bends allow for expansion. The plan of the piping, Fig. 5, shows the numerous bends between the boiler outlet valves and the turbine throttles. The main 12-in. headers are anchored between the 180-deg. bends, but at no other points. This piping system is expensive, but insures continuity of operation at a minimum of operating expense.

In Fig. 6 is shown the turbine exhaust-pipe layout. Any turbine can be run with its own condenser or either condenser of its immediate neighbors, but with no others.

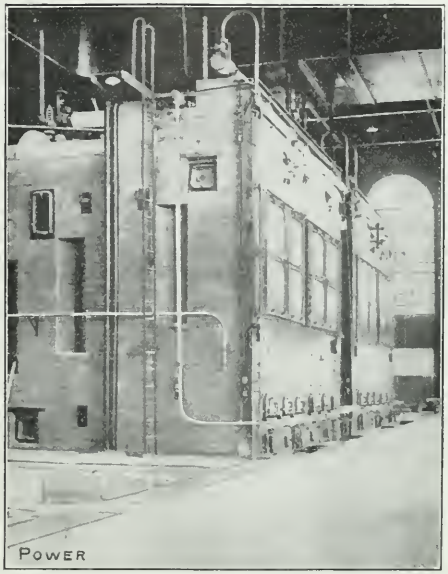


Fig. 4. Boiler Room, Showing Four of the Ten Water-Tube Boilers

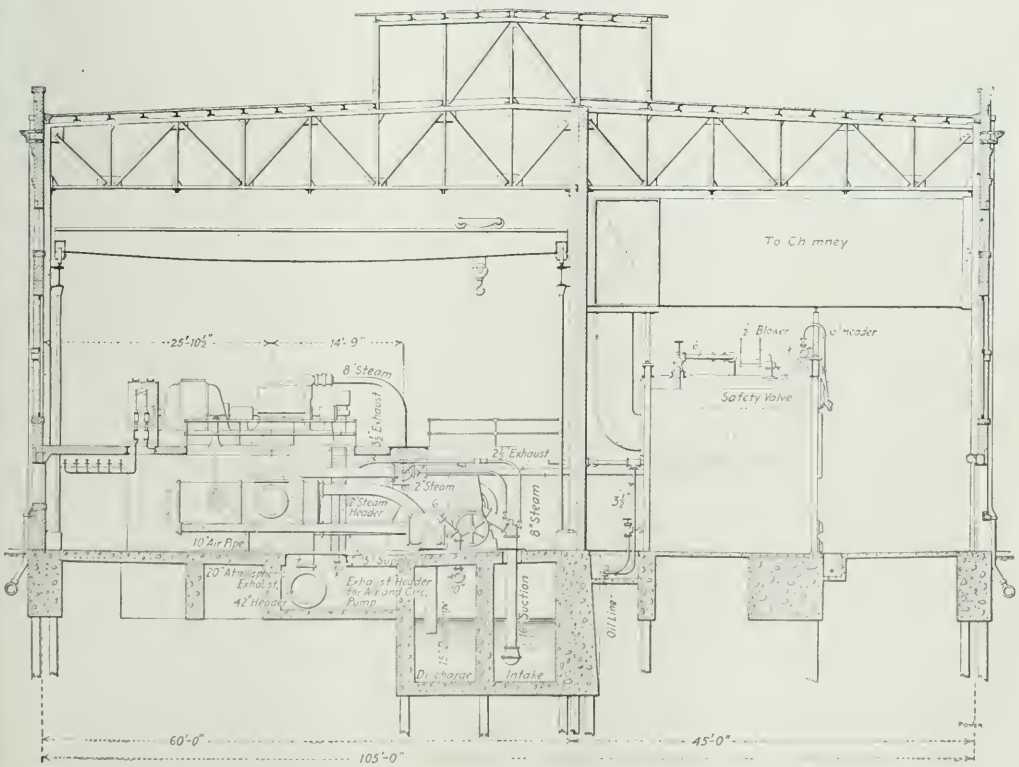


Fig. 3. Elevation of Engine and Boiler Rooms

The remote possibility of all three condensers to which any turbine has access being out of commission does not justify the heavy expense of bypassing the exhaust steam. The valves on the exhaust line between the condensers have bevel-gear operating wheels, to permit operating from the floor of the generator room. These valves will all be motor operated as soon as motors can be installed.

Condensing Apparatus

A 3000-hp. condenser is furnished for each turbine. Circulating water is taken from the inlet conduit at about 62 deg. F. and is pumped by 16-in. centrifugal pumps directly connected to vertical engines. The air pumps discharge into a hotwell. A condensing unit is shown in Fig. 7 in which the condenser proper is shown in the background. The size of the condensing units in proportion to the turbines is sufficient to provide condensing surface for the heaviest peak load which may ever be carried.

Exhaust steam from the condensing units is piped directly to an open feed-water heater and heats the feed water to about 210 deg. An outside-packed 14 and 9 by 18-in. duplex pump feeds the boilers.

A section of the building is devoted to baths, toilet rooms, etc., which equal those found in the best club houses and hotels. The bath rooms are on the first floor; the toilet rooms on the generator-room floor. On the third floor is a reading room where the latest technical journals will be found, and the chief engineer's office is directly behind this room.

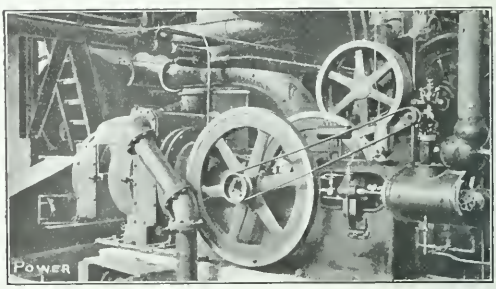


Fig. 7. Condenser Unit

For most of the above data the writer is indebted to the general superintendent, W. H. Tucker, who is responsible for the entire supervision of the plant, substations, distribution, etc. L. E. Murphy, chief engineer, is responsible for the operation of the plant itself.

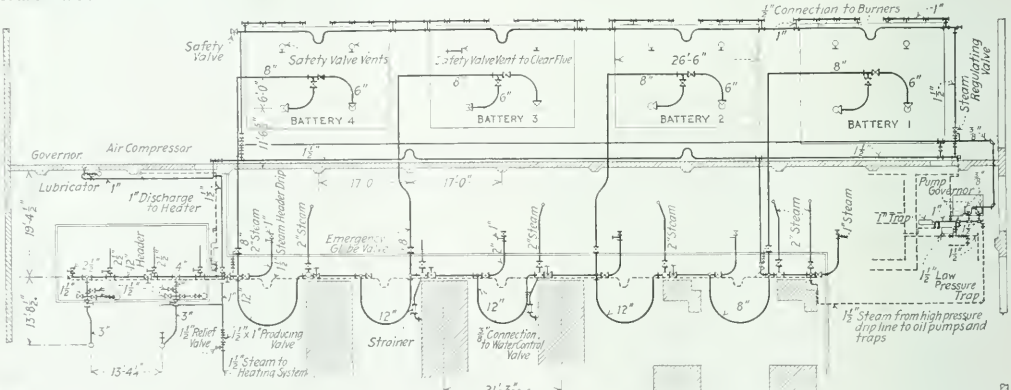


FIG. 5 PLAN OF STEAM LINES

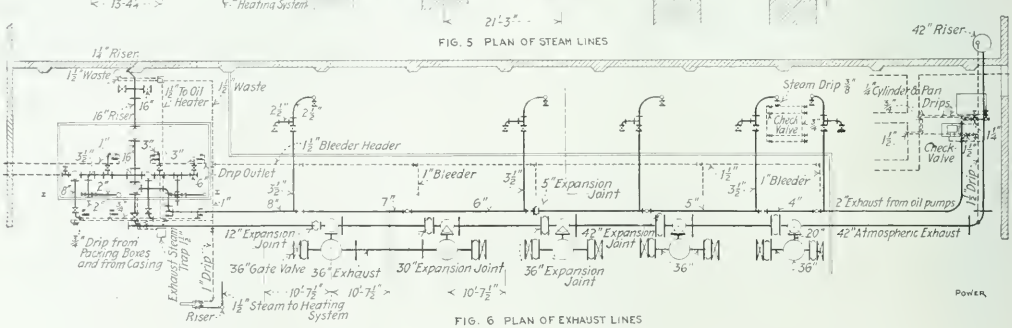


FIG. 6 PLAN OF EXHAUST LINES

Figs. 5 and 6. Plan of Steam and Exhaust Lines

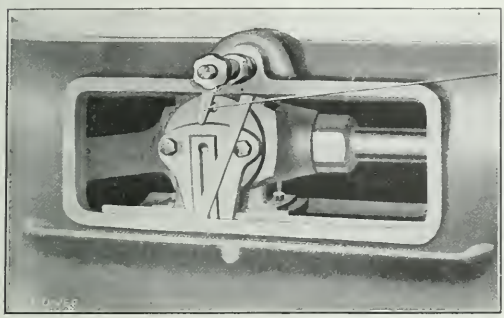
PRINCIPAL EQUIPMENT OF THE JACKSONVILLE, FLA., MUNICIPAL ELECTRIC-LIGHT PLANT

No.	Equipment	Make	Purpose	Kw.	Volts	Phase	Cycles	Size	Hp.	Manufacturers
2	Turbines	Steam	Main units	1500	6600	3	60			General Electric Co.
2	Turbines	Steam	Main units	1500	6600	3	60			Allis-Chalmers Co.
1	Crane	Power	Gen. room					30 ton		Niles-Bement-Pond Co.
10	Boilers	Water tube	Steam gen.							Babcock & Wilcox Co.
1	Chimney	Concrete	Flue gases					12x20"		Concrete Construction Co.
4	Condensers	Surface	Turbines						3000	C. H. Wheeler Mfg. Co.
1	Pump	Duplex	Boiler feed					14x9x18"		Warren Steam Pump Co.

Ideal Reducing Motion

The improved "Ideal" indicator reducing motion, which has been developed for use on Ideal Corliss-valve engines, is shown herewith. The mechanism is inside the frame, where it is constantly bathed with oil. The linkage within the frame oscillates a spindle in unison with the piston.

This spindle is mounted on an oil-tight bearing in the engine frame and transmits the movement to the lever outside the frame to which the indicator cord is attached. The lever has a hand-knob and clutch, so that by a slight endwise movement on the spindle, the lever can be in-



Ideal Reducing Motion

stantly engaged or disengaged to start or stop the indicator without disturbing the cord or any other connections.

This reducing motion is made by A. L. Ide & Sons, Springfield, Ill.

Putting Crankpins in Large Engines

By J. N. Lucas

Relative to the method of putting a crankpin in a 5000-hp. engine, as described by W. J. Maxwell in the Feb. 18 issue, page 233, it is surprising that after having heated the crank disk with a gasoline torch for over 12 hr. it could not be made hot enough to complete the job by the method originally intended. The accompanying engraving gives an idea of how the crank disks of large engines are heated rapidly with very simple apparatus.

Large C-clamps, Fig. 1, screwed on each side of the crank, as shown in Fig. 2, serve as supports for iron plates, which form a box-like enclosure around the pin bore in the crank. Sheet asbestos is then put around the plates to retain the heat when heating the crank.

Underneath the crank, a piece of $\frac{1}{16}$-in. sheet iron A, bent like a large pan, having holes punched in the bottom for draft, is attached to the shaft and to the C-clamps with wire, keeping the pan suspended close to the crank. A charcoal fire is kept going in this pan while the crank is being heated with the burner B. The charcoal fire retards the escape of the heat furnished by the burner.

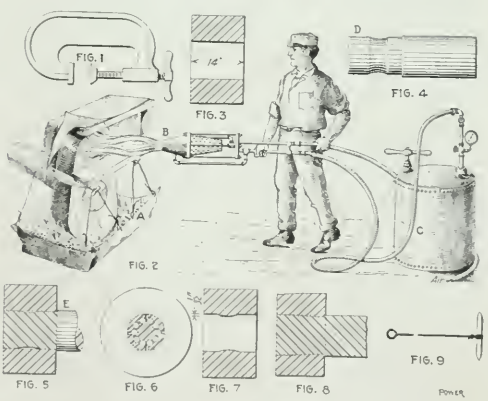
A kerosene tank C (usually of 30 gal. capacity) is used; the pressure carried is 25 lb. and is maintained by a hand pump. When the flame is made to play directly in the pin bore it will not take more than from four to five hours to bring a very large crank to a dark-red color corresponding to a temperature of about 800 deg. C.

The job of putting in a crankpin confronted the writer while he was in one of the French navy yards. The following plan was thought of, but it was desired to first ascertain that it would prove satisfactory. A disk of forged steel with an outside diameter of 37 in., a hole having a diameter of 15 in. and a depth of 14 in. (Fig. 3) was heated and the expansion, at a temperature of about 800 deg. C., found to be $\frac{1}{16}$ in. A pin, Fig. 4, was turned to $15\frac{1}{16}$ in. diameter with a groove D $\frac{1}{32}$ in. deep in a length of 6 in.

When the disk was of the right temperature the pin was forced into it. Naturally while the disk was hot, there was a space at E, Fig. 5, between it and the groove in the pin. When the piece became cold, holes were bored in the pin, Fig. 6, and four cuts chiseled quarterly so the pin could be extracted without injuring the surface of the bore. The inside of the hole was examined and measured and it was found that the metal had contracted to fit the shape of the pin, Fig. 7, which was the result desired.

Now being positive that this method was satisfactory it was decided to use a similar one in putting the crankpin in the engine awaiting repair.

The hole in the crank disk was 382 mm. (15.039 in.) in diameter, with a depth of 405 mm. (15.944 in.). The disk 306 mm. (12.047 in.) across. The expansion, at about 800 deg. C. figured to 2 mm. (0.078 in.). The new crankpin was turned 2 mm. (0.078 in.) larger than



How Crank Disk Was Heated and Crankpin Fitted to Disk

the hole at its extreme end, with a taper of $\frac{3}{4}$ mm. (0.029 in.) in the full length, as shown in Fig. 8.

While the heating operation was going on a pin-bore gage, Fig. 9, was made of $\frac{1}{2}$-in. steel having a length, from point to point, equal to the large diameter of the pin. After heating about $4\frac{1}{2}$ hr., the hole had expanded enough to admit the gage, consequently the crankpin was forced in with ease and left to cool. What happened is shown by the dotted lines in Fig. 8. The disk, after cooling, contracted, closing tightly around the tapered pin.

This method of putting in crankpins was adopted in the shops of that navy yard.

Testing Oils for Sulphur

By William Pattern

It is often advantageous for an engineer, using fuel oil or crude oil as fuel for his boilers, to know the amount of sulphur the oil contains. This can easily be done by the engineer, with a few simple chemicals and pieces of chemical apparatus.

Outfit

The following is a list of apparatus required for making a qualitative and quantitative test, the only expensive item being the analytical balance, which would cost from $12 to $40; $\frac{1}{4}$-in. glass tubing medium heavy, two 500-c.c. beakers, 1 oz. metallic sodium, 1 qt. saturated bromine water, one 4-in. sand bath (iron saucer-like dish), one bunsen burner with rubber tubing, one package of spun glass (wool), bunsen-burner tripod stand, one piece of wire-gauze netting, one mortar and pestle, one 1-lb. bottle of hydrochloric acid c.p., 1 oz. of barium chloride crystals c.p. This outfit may be bought at any chemical-supply house at a cost of about $3.

Should it be desired to determine the actual percentage of sulphur by weight, in the oil, it will be necessary to purchase the following additional laboratory equipment: one analytical balance, one set of weights (50 gm. to 1 mgm., and one 10-mgm. rider), six $1\frac{1}{4}$-in. procelain crucibles, one $2\frac{1}{2}$-in. glass filter funnel, one package of first-quality filter paper, 1 oz. sulphuric acid, c.p., one filter stand, one wash bottle (can be bought all ready fitted up for use), one box of blue litmus paper (in books), one pair of bent iron tongs. This outfit will cost exclusive of the scales about $10.

Making Test Tube

Cut off piece of $\frac{1}{4}$-in. glass tubing 6 in. long and, holding an end in each hand with the center in the flame of a bunsen burner, rotate the tube constantly; when the glass becomes soft, steadily pull apart. Now hold the thin thread-like end of the tube in the flame of the burner with a constant rotating motion, until it melts and the result is a small closed tube 3 in. long. Rotating the tube as before, place the closed end in the flame and heat to redness, remove from the flame quickly and blow rather strongly in the open end until a bulb about twice the diameter of the tube is formed. Cut off the tube with a file, making it 2 in. in length.

Testing for Sulphur

The bulb is now half filled with the oil to be tested and three or four $\frac{1}{16}$-in. square pieces of metallic sodium put in the oil. Next push down in the tube a small wad of glass wool to within a short distance of the bulb, put three or four small pieces of metallic sodium on top of the glass wool and fill the tube to the top with more glass wool. Fill the sand bath with clean sand, bury the bulb of the tube containing the oil in the sand and place the lighted bunsen burner under the sand bath. Heat gradually for about 30 min. and then increase the heat until smoke issues from the mouth of the tube, when a light should be applied to the mouth of the tube and the vapor allowed to burn.

When the flame at the mouth of the tube goes out, remove the tube with the tongs from the sand bath, and pass it back and forth through the naked flame of the bunsen burner until all the oil is consumed. Put the tube in the mortar which has already been supplied with a small quantity of distilled water to which a few drops of saturated bromine water has been added. Cover the mortar quickly with a watch glass, as any free sodium which may be uncombined will burn and spatter.

Pound up the tube thoroughly with the pestle. Fold a filter paper and fit it in the glass funnel, wetting it with distilled water to make it stay. Place a beaker under the funnel and pour the contents of the mortar into the filter gradually, letting the liquid run down a rod placed against the lip of the mortar.

Wash out the mortar thoroughly with warm, distilled water, using the wash bottle, and run the contents through the filter. Wash the filter paper thoroughly with warm, distilled water from the wash bottle.

Place the beaker on the heating stand with a piece of fine wire gauze below. Add about 50 c.c. of saturated bromine water and boil the contents of the beaker until colorless to expell all bromine in the solution. Then add a few drops of chemically pure hydrochloric acid until the solution in the beaker turns blue litmus paper red, and boil again until colorless.

Wait until the boiling ceases and then add a few crystals of barium chloride on the tip of a small penknife blade. Boil again for 3 min. and if any sulphur be present a white precipitate of barium sulphate will be formed rapidly. A light precipitate indicates a small percentage of sulphur and *vice versa*.

Percentage of Sulphur

Should it be desired to weigh the barium sulphate to determine the percentage of sulphur by weight, proceed as follows:

Filter off the barium sulphate as in the previous operation to remove the glass. Filter very slowly and carefully, as barium sulphate is liable to work through the filter paper, and use only the first quality of filter paper. Wash the beaker thoroughly with hot water, using the wash bottle, and run the water through the filter. Wash the filter paper down three times with hot water from the wash bottle which can be placed on the wire gauze on the heating stand and heated with the bunsen flame. Let the filter drain and remove it carefully. Fold up the filter paper and place it in a porcelain crucible of known weight. Heat the crucible on a clay triangle over the naked flame of the bunsen burner until the filter paper is reduced to white ash. Let the crucible cool for 3 min., add three or four drops of diluted (1 to 4) sulphuric acid and warm very carefully until the acid ceases to give off white fumes. Then heat with the full force of the burner for 2 min. After cooling, weigh the contents. The increase in weight of the crucible will be the weight of the barium sulphate. This weight multiplied by the factor 0.137 will give the weight of the sulphur. All weights should be within $\frac{1}{2}$ mgm.

When weighing the sample of oil, put the bulb in a cup and weigh, then put the oil in the tube and weigh the tube, cup and oil. The difference in weight equals the weight of oil.

The following will serve as an illustration of the weighing and calculations involved:

7.1850 gm., weight of cup, tube and oil

6.5740 gm., weight of cup and tube
0.6110 gm., weight of oil
5.4397 gm., weight of crucible and precipitate
5.4184 gm., weight of crucible
0.0213 gm., weight of barium sulphate

The weight of the sulphur would then be

$$0.0213 \times 0.137 = 0.0029181 \text{ gm.}$$

and the percentage of sulphur in the oil.

$$\frac{0.0029181}{0.6110} = 0.00477 = 0.477 \text{ per cent.}$$

The amount of sulphur in coal can also be determined by this method.

Operating the Plant under Difficulties

SYNOPSIS—Difficulties met in the installation of an isolated plant, and incidentally a considerable reduction in the cost of power over purchased current.

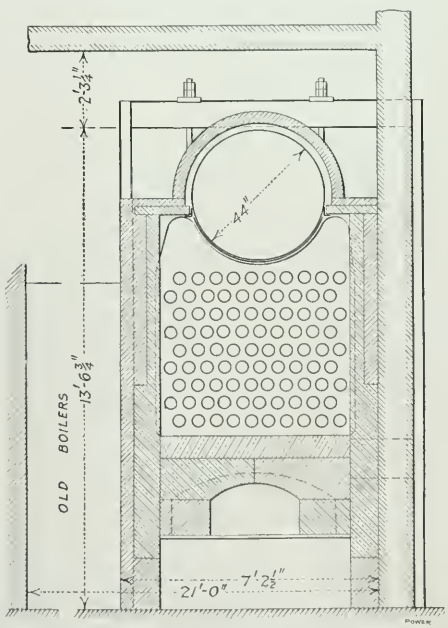
For three years the Mason-Seaman Transportation Co., of New York City, has been buying electric current for lighting and power for one of its buildings, a four-story brick structure Two horizontal tubular boilers have been operated to supply steam for heating and for a Westinghouse two-stage air compressor. The company operates the largest taxicab business in the city, and in the building just referred to houses about 600 machines. Due to the open driveways into the building, and the open windows to allow the exhaust gases from the machines to escape, 22,000 sq.ft. of coil surface is required to heat the building. Steam is also required for vulcanizing the tires, and on the top floor there is a good-sized machine shop for repairing and assembling new cars which are purchased in the rough by the company. The power load was, therefore, considerable, and at 5c. per kw.-hr. paid to the Edison Co., it amounted to a sum worth considering in the course of a year.

C. J. Rankin, chief engineer of the plant, decided that as long as boilers had to be operated for heating, a large saving could be effected by generating their own current for lighting and power. After using steam in an engine about 85 per cent. of the heat can be used to advantage in a heating system, so that in the present case the current for lighting and power should cost but very little more than the interest and depreciation on the investment for the generating equipment.

During the summer a 50-kw. C. & C. three-wire generator direct connected to an 11x12-in. Ames simple engine, was installed. It was put in operation on Aug. 22, and up to Feb. 15 was run 23½ hr. per day with such satisfactory results that it was decided to enlarge the plant, this being necessary as the company is erecting a new building beside the one it now occupies. On Feb. 15 a 100-kw. unit was put in operation and a 75-kw. unit is now being installed. These are of the same type as the 50-kw. machine, and the engines are 11x11 in. and 13x12 in., respectively. Since installing the 100-kw. machine it has been run daytimes under 80 per cent. load, and the small machine has been run nights under 95 per cent. load. When the new building is completed the generating equipment will be taxed to the limit.

Up to the time the large unit had been put in operation, Edison breakdown current had been maintained in the plant, but it has now been eliminated altogether. As shown by the records of the plant, the cost of operation has been less than 2c. per kw.-hr., as compared to 5c. formerly paid.

It was an easy matter to install the generating equipment, but the real difficulty came in equipping the boiler room with sufficient additional boiler capacity to handle the engine load. The boiler room was only 21 ft. wide by 37 ft. long, with head room of 15 ft. 10 in. It was impossible to install enough fire-tube boilers in this space to handle the load, and it was necessary to replace the two already installed with water-tube boilers of sufficient capacity. During the change, however, the plant had to be kept in operation, and one water-tube boiler had to be



Section through Single-Drum Boiler and Setting As It Will Appear

installed, which would temporarily carry the load while the old return-tubular boilers were being removed and a second water-tube boiler was being put in place. The space between the setting of the return-tubular boilers and the wall opposite was only 7 ft. 2½ in., and as previously stated the head room was 15 ft. 10 in. A boiler which would carry the load and fit this space was hard to find, but finally the McNaull Boiler Manufacturing Co., of Toledo, Ohio, agreed to install one of its single-drum water-tube boilers, specially designed for the purpose. The boiler contains ninety 4-in. tubes 16 ft. long, with 1610 sq.ft. of heating surface. The drum is 44 in. in

diameter by 18 ft. long, and the grate 5 ft. 4 in. by 6 ft. 9 in. A McClave-Brooks grate was used and an Argand blower was installed to force the boiler considerably beyond its rated capacity of 160 hp.

To make matters worse, the draft was not good, as the stack was only 24 in. square and 91 ft. high. Due to the limited space, no provision could be made for cleaning the boiler, and on Mar. 1, after it had been in operation for two months, the flue ashes were over the bottom tubes at the rear of the setting and at the bridgewall near the sides of the setting. The space at the center had, of course, been kept clear by the force of the draft from the Argand blower. Besides there were chinks in the setting, and the top of the boiler was not covered, so that there was ample opportunity for air leakage into the combustion chamber.

Since Jan. 14, the boiler has been supplying the entire demand of the plant, and this from Jan. 14 to Feb. 15 consisted of the 50-kw. generating unit, the two-stage Westinghouse air compressor rated at 40 hp. and running 75 per cent. of the time, live steam as well as exhaust from the engine for the heating, and also steam for the following pumps: one $2\frac{3}{4}$ and $4\frac{3}{4}$ by 4-in. house pump running 75 per cent. of the time; one $4\frac{3}{4}$ and 5 by 5-in. sump-well pump running 30 per cent. of the time, and one 6 and 4 by 6-in. boiler-feed pump running intermittently to supply the feed water. Since Feb. 15, 80 kw. has been generated for light and power, instead of 50, thus putting additional load on the boiler. About eight tons of No. 2 buckwheat coal was burned per day of 24 hr.

Considering the adverse conditions, the results are remarkable. That the boiler was able to carry the overload is worthy of comment, and the cost of current for a plant of the size and the conditions under which it was operated is low.

On Mar. 1 the installation of the second water-tube boiler had been nearly completed. This is a two-drum boiler rated at 249 hp. It is of the same length as the other, has 135 four-inch tubes and it is equipped with the same type of grate and blower. When this boiler is ready to supply steam, and the first boiler has been provided with a proper setting, better results are expected. The engineer hopes to produce current for light and power at an operating cost approaching 1c. per kw.-hr., and when the heating system is in full blast he can probably do it without any difficulty. Further results from this plant will be watched with interest.

Power Transmitting Capacities of Pulleys

By John S. Leese

SYNOPSIS—A number of tests showed the maximum transmitting capacity of paper pulleys to be 29.8 per cent. better than cast-iron and 107.7 per cent. better than wood pulleys.

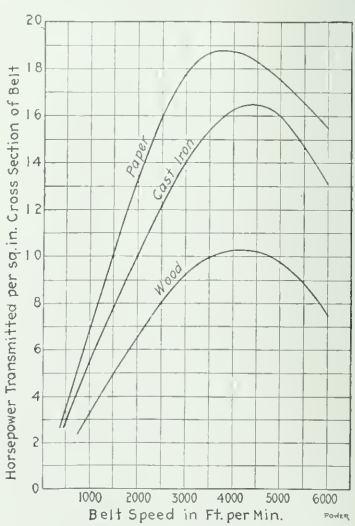
The writer recently came across the accompanying data which are the results of tests carried out less than two years ago but which he was then unauthorized to publish. The object of these tests was to determine the relative transmitting powers of wood, paper and cast-iron pulleys with leather belts, and the accompanying results, the average of twenty independent readings at each speed, came rather as a surprise to the interested parties.

Belt slip and tension were calculated at the same values for each pulley so that a working basis fair to all the pulleys was obtained. The belt tension (the tension in the driving side plus half the tension in the slack side) was constant at all speeds. The results show the maximum transmitting capacity of paper pulleys to be 29.8 per cent. better than cast-iron and 107.7 per cent. better than wood pulleys, the maximum figures for each pulley occurring at different speeds.

It may be noticed that in each case the capacity falls off more rapidly after passing the maximum than it increases before reaching this value. This tendency is more marked in the cast-iron pulley. The wood pulley "hangs on" around its maximum over a greater range of belt speeds than either of the others.

During these tests measurements were made to compare the temperatures of the surfaces of each pulley, first with constant horsepower (8 hp. per sq.in. cross-section of the belt) and second with constant belt speed (3500 ft. per min.). The results obtained showed that with constant power, wood pulleys were the hottest, paper next, and cast iron coolest. With constant speed the paper was the hottest and the wood a very close second.

At the completion of the experiments the belt speed was increased with the object of determining the speed



Belt Speed-Horsepower Curves for Different Pulleys

at which the wood pulley would begin to char. This was found to occur at approximately 7200 ft. per min. The paper pulley was next tried for charring, but no trouble ensued up to about 7900 ft. per min. It was im-

possible to go above this speed as the belt flew off the pulleys repeatedly when it was attained. After several attempts to go higher, one of the experimenters had a narrow escape from the flying belt as it came off the pulleys, and further trials were abandoned.

New American-Ball Paper-Mill Engine

The fundamental requirements of a variable-speed paper-mill engine are a speed range equivalent to the desired speed range of the rolls, and, as near as possible, perfect regulation at all speeds. To meet these requirements the American-Ball four-cylinder paper-mill engine, illustrated herewith, has been designed.

The four cylinders are arranged in pairs at right angles, making an engine of two units, each of which has a vertical and horizontal cylinder, Fig. 1. One vertical and one horizontal piston drive one crankpin, and the other vertical and horizontal pistons a second crankpin 45 deg. from the first, so that there are eight power strokes per revolution, evenly distributed. A counterweight on each crank transfers the horizontal reciprocating forces from a horizontal to a vertical plane, in which they meet equal and opposite reciprocating forces from the vertical reciprocating masses, which, therefore, neutralize unbalancing and permit operation at from 100 to 500 r.p.m. The engine may be operated at as low a speed as 50 r.p.m. with good regulation, so that a total speed range of 8 to 1 and even 10 to 1 may be obtained. The engine may be coupled directly to the line shafting.

In Figs. 2 and 3 are shown the speed-changing and governing mechanisms. Two governors are used, each of standard type, specially improved and adapted to this particular service. The first governor is used as an automatic safety stop and is placed nearer the steam-supply pipe, at the right of Fig. 2. It is belt driven from the engine shaft and has an automatic tripping mechanism. The steam valve remains wide open throughout the normal range of speeds for which the engine is designed, but if the speed exceeds the predetermined limit the mechanism is tripped and the weighted lever closes the steam valve. At all normal speeds this governor valve has no throttling effect.

The second governor, at the left in Fig. 2, controls the engine speed and is driven through the variable-speed friction device also shown.

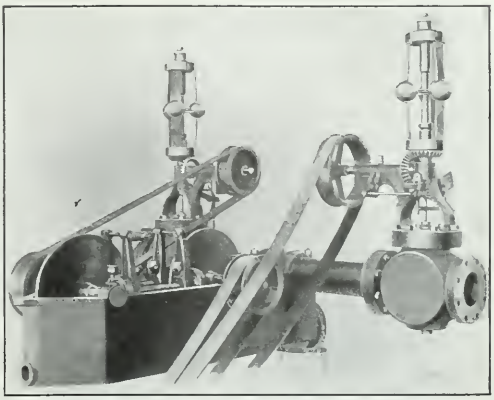


Fig. 2. View of the Ball Governor

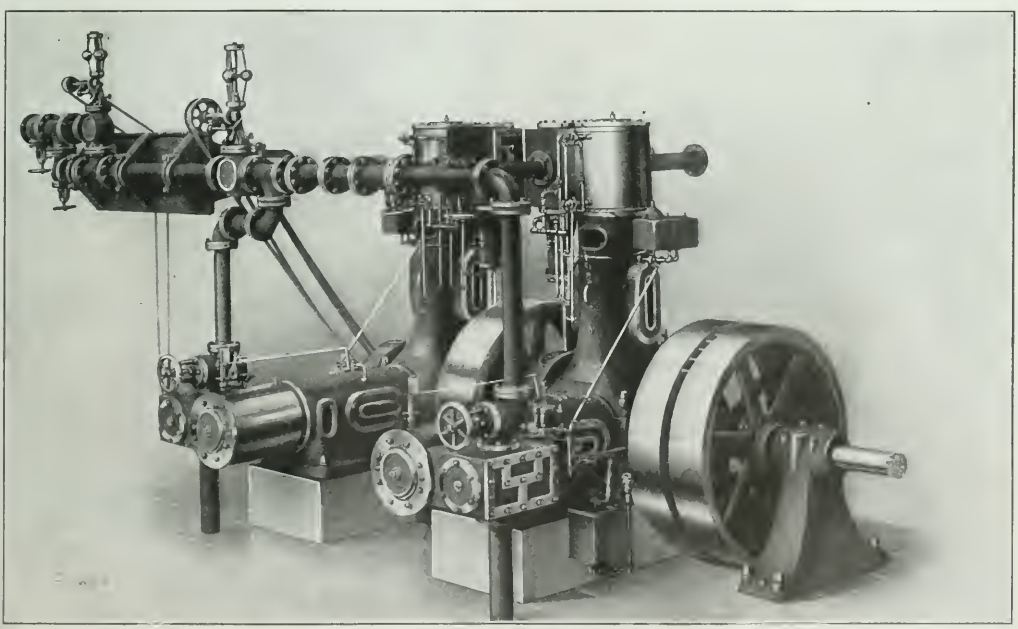


Fig. 1. American-Ball Four-Cylinder, Variable-Speed, Paper-Mill Engine

To prevent speed surges, a standard governor has been equipped with a mechanism comprising stabilizing springs and an oil pot. The piston of the oil pot receives motion from the governor stem, through the spring stabilizing device, which absorbs shocks induced by sudden changes in the speed of the governor balls. This stablized

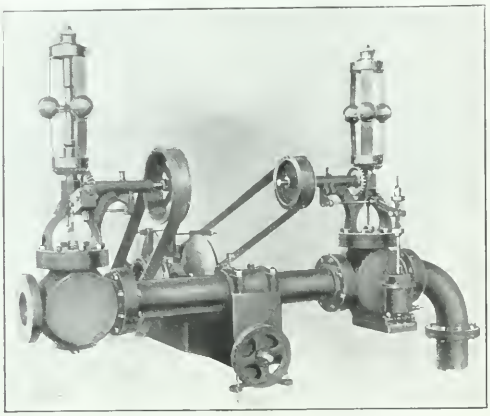


Fig. 3. Ball Governor and Speed-Changing Mechanism

governor is driven from the engine through a variable-speed friction device. A belt from a pulley on the engine shaft drives a pulley on the friction device, which drives a second pulley through two disks and two pairs of friction wheels. Any speed from minimum to maximum may be imparted to the second pulley, which, in turn, drives the governor.

The two large iron disks are each keyed to a pulley shaft. Bearing on the surface of these disks are four small friction wheels, one on each side of each disk. The driving disk, keyed to the shaft of the driving pulley, rotates the two friction wheels, held against it by springs, and the second pair of friction wheels drives the second disk and the pulley keyed to its shaft.

The speed is changed by shifting the position of the friction wheels, which are carried by four rockers located in pairs; each pair is held to a shaft which passes through guides and may be shifted as desired by a chain wheel and lead screw cut at one end. Each pair of rockers is held together by springs, thus keeping the friction wheels firmly against the disks. All bearings are of the ball-bearing type.

This engine is built by the American Engine Co., Bound Brook, N. J.

Flexible Metallic Combination Hose

A new coupling, known as the J-M flexible metallic combination hose, consists of a durable rubber hose, protected against outward injury by a stout metal armor. The armor is made in the form of a ribbon, with crimped edges, forming, when wound, a continuous interlocking flexible spiral, which is designed to be practically pressure-tight in itself, without the inner tube.

As the interlocking construction of the spiral restricts the curvature of the hose, sharp bends are impossible. Consequently, the inner tube cannot kink or flatten, and is always open to its full diameter, permitting an unrestricted flow of steam, gas or fluid.

Owing to its strength, the armor is practically proof against damage from the outside. Service tests show that it will resist a crushing strain of 300 to 800 lb. to each four turns of the spiral, depending on the size of the hose, while it is capable of withstanding high internal-working pressures.

The inner tube is never subject to any pulling strain, as the armor is stretched to its maximum length before the former is inserted. All the working strain comes on the armor, which is tested to resist an end pull or thrust of 1000 to 2000 lb. The exterior surface does not become excessively hot when used for steam service, and can be conveniently handled.

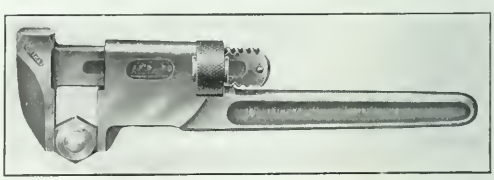
Specially designed couplings of malleable iron or brass are furnished with each length of hose. Each coupling consists of an outer sleeve, into which the metal armor is threaded and riveted, an internal nipple, tapered on one end to fit tightly inside the inner tube, and the lock or binding nut which serves to wedge the internal nipple into the inner tube and hold it tightly against the inner walls of the outside sleeve. The outer end of the internal nipple is furnished in male or female type, threaded to meet any standard requirement.

This hose can be furnished in any length, in any inside diameter up to 12 in., of any metal, and for all working pressures. It is also made with an inside pressure-tight metallic lining as well as outside metal armor, for suction service, oils, etc. For washing out boilers, for roundhouse work, and for use in other places where steel would corrode, copper armor is used.

This hose is made by H. W. Johns-Manville Co., New York City.

Hammer-Head Monkey-Wrench

The hammer-head jaw of the wrench shown extends outward instead of opening toward the handle to gain a longer leverage in proportion to the size of the nut. The handle contains a housing through which the jaw slides,



New Monkey-Wrench

and a nut guard protects the adjustment of the wrench. This guard keeps the adjustment from shifting through jar or vibration.

The wrench is made of drop-forged steel, in a variety of sizes, by the Trimont Manufacturing Co., Roxbury, Mass.

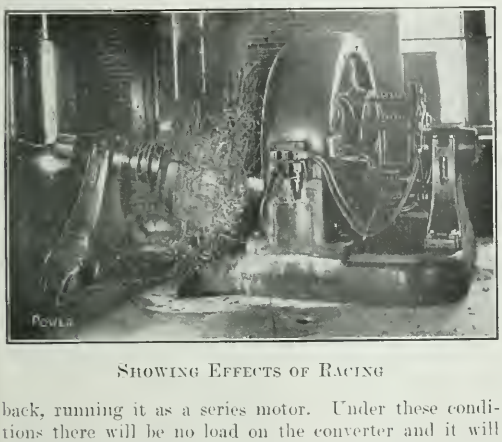
The custom of whitewashing the surface of loaded coal wagons has been inaugurated in Germany as a security against coal pilfering during transportation. Where the experiment has been tried it is said to have been successful.

ELECTRICAL DEPARTMENT

Racing of Rotary Converter

The accompanying photograph shows the result of the racing of a 300-kw. rotary converter, which occurred on Apr. 5 at one of the substations of the Springfield, Troy & Piqua Ry. Co., Springfield, Ohio.

When a series-wound rotary converter is running in parallel with other machines supplying a direct-current system, and its alternating-current supply is interrupted without the circuit-breaker on the direct-current side being opened, the current from the other machines will feed



SHOWING EFFECTS OF RACING

back, running it as a series motor. Under these conditions there will be no load on the converter and it will immediately run away, unless some protective device opens the direct-current circuit. This is what happened in the present case.

The converter was protected by a low-voltage release, also a speed-limit device on the end of the armature shaft. This consists of a revolving contact piece, which under the action of centrifugal force, when above a certain rotative speed, makes contact with a short-circuiting ring, thus demagnetizing a solenoid on the circuit-breaker, dropping the plunger and opening the circuit.

For some unknown reason this device failed to operate, although it had been inspected recently and found in working order. Besides wrecking the machine, as shown, the building was damaged to some extent.

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Decreasing Frequency of Transformers*

BY F. A. ANNETT

The losses in a transformer are divided into two parts, namely: Iron losses and copper losses. The iron losses are due to hysteresis caused by the molecular friction of the iron and to eddy-current losses caused by the varying magnetic flux inducing electromotive forces in the core. The iron losses are independent of the load, for they are dependent on the magnetic density in the core, which is about the same at no load as at full load and go on while the transformer is connected to the line.

The copper, or I^2R, losses increase with the load. The combined effect of the iron and copper losses is to heat up the coils and core so that the amount of power a transformer is capable of delivering is limited by the heating effect. The watts expended in heating the transformer is the difference between the watts input at the primary and the watts output at the secondary.

The hysteresis losses vary as the 1.6 power of the magnetic density and directly as the frequency. The eddy-current losses vary as the square of the frequency and magnetic density.

Considering the e.m.f. induced in the primary equal and opposite to the impressed e.m.f., a condition approached in a well designed transformer under no load. Let

E_p = Impressed primary voltage;
ϕ = Total flux through the core;
T_p = Number of turns in series on the primary coil;
f = Frequency in cycles per second.

$$\text{Then } E_p = \frac{4.44\,\phi\,T_p\,f}{10^8} \qquad (1)$$

From the formula (1) it is evident that if E_p and T_p are constant, and the frequency (f) is changed, the flux (ϕ) must change in inverse proportion; that is, if the frequency is decreased the flux must increase in the same proportion. Let

V = Volume of iron in cubic inches in the core of a given transformer;
B = Magnetic density in lines of force per square inch;
w = Watts loss per cubic inch per cycle for a density B;
f = Frequency in cycles per second;
W_h = Total watts loss due to hysteresis = Vwf.

If the frequency f is changed to the frequency f' the magnetic density will change from B to $B' = \frac{Bf}{f'}$. Let

w' = Watts loss per cubic inch per cycle for a density B';
W'_h = Total watts loss due to hysteresis for a frequency f'.

$$\text{Then } w' = \frac{w\,B'^{1.6}}{B^{1.6}} = \frac{w\left(\frac{Bf}{f'}\right)^{1.6}}{B^{1.6}} = \frac{w\,B^{1.6}f^{1.6}}{B^{1.6}f'^{1.6}} = \frac{wf^{1.6}}{f'^{1.6}}$$

$$\text{And } W'_h = Vw'f' = \frac{Vwf^{1.6}}{f'^{1.6}}\,f' = \frac{Vwf^{1.6}}{f'^{0.6}}$$

Since V = Constant; let

W = Watts loss per cycle for a frequency f = Vw.

$$\text{Then } W'_h = \frac{Wf^{1.6}}{f'^{0.6}} \qquad (2)$$

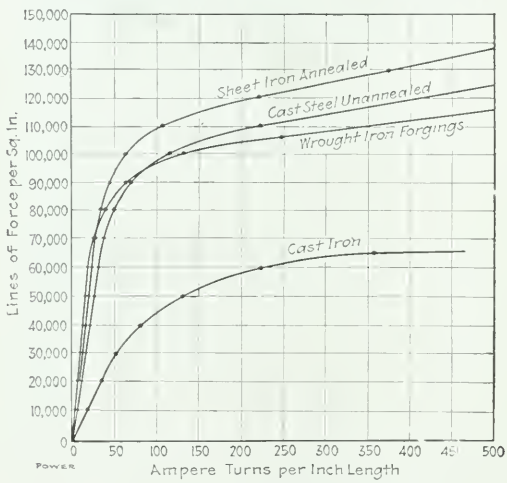
*This article was prepared in response to several inquiries from readers relative to the effect on the transformer losses, of changing from 60 to 50 cycles.

That is, the watts loss (W'_h) due to hysteresis in a given transformer for any frequency is equal to the watts loss per cycle (W) times the 1.6 power of the frequency (f) for which the transformer is designed, divided by the 0.6 power of the frequency (f') that the transformer is working on.

Since the eddy-current losses vary as the square of the frequency and magnetic density they will remain about constant for any frequency in a given transformer, for the magnetic density varies inversely as the frequency.

It is evident from formula (2) that if the frequency is decreased the losses due to hysteresis will be increased and, as stated, the hysteresis and eddy-current losses should be kept as small as possible, for they are going on all the time as long as the transformer is connected to the line; also the magnetic density varies inversely as the frequency, requiring greater magnetizing current.

Up to a magnetic density of about 70,000 lines per square inch in a good quality of transformer iron (see the accompanying curves), the flux increases directly as the ampere turns per inch of length. At this density



Ampere Turns Plotted against Lines of Force.

about 25 ampere turns per inch length of core are required to set up the flux. At 100,000 lines per square inch it requires 65 ampere turns per inch length and at 140,000 lines per square inch (this is about the point of saturation) it requires about 600 ampere turns per inch length.

The magnetizing current may be expressed as

$$I_m = \frac{L\,(IT)}{T_p}$$

where

I_m = Total current required to set up the flux through the core;

(IT) = Ampere turns per inch length = average turns, T, in series per inch of length times I the total current in the coil;

L = Mean length of transformer core;

T_p = Total number of turns in series on the primary coil.

Since the flux increases inversely as the frequency it is evident that if the frequency is greatly decreased the flux will become very high, and above 70,000 lines of force per square inch, the ampere turns (IT) per inch length increase very fast. If this element becomes very large (I_m) the total current required to set up the flux also becomes very large, although this current is 90 deg. behind the e.m.f. and is wattless. It is, nevertheless, loading up the line and alternator, and reducing the power factor of the whole system, thereby reducing the useful working capacity.

Since, the current required to supply the iron losses is in phase with the e.m.f. and the magnetizing current is 90 deg. behind the e.m.f., the no-load or exciting current will be the resultant of the magnetizing current proper and the current required to supply the core losses, and may be expressed by the formula:

$$I = \sqrt{\left(\frac{W_h + W_e}{E_p}\right)^2 + \left(\frac{L\,(IT)}{T_p}\right)^2}$$

W_e being the watts loss due to eddy currents, and the cosine of the angle of lag between this resultant and the e.m.f. will be the power factor of the transformer. Therefore, the greater the magnetizing current component, the lower the power factor of a given transformer at no load; this will cause a lower power factor at full load.

The increase in the magnetizing current is dependent upon the magnetic density per square inch for which the transformer is designed. Assume that the magnetic density is low, say, 30,000 lines per square inch. If the frequency is decreased by one-half, the magnetic flux will be doubled, and the exciting current will be approximately doubled, but if the transformer is designed to work at a magnetic density of 60,000 lines to the square inch, and if the frequency is decreased by one-half, the magnetic flux will be doubled as before, and the magnetizing current will be increased approximately eighteen times.

Unequal Alternator Voltages

Referring to the inquiry by H. J. B. and the answer thereto, printed on page 506 of the Apr. 8 number of POWER, it may be of interest to point out that unequal voltages from alternators of the same size and type, running at equal speeds and with equal field excitations, could be due to eccentricity of the armature of one machine or to a slight difference in the air-gap lengths of the two. It is difficult to build two machines with air gaps of precisely the same effective lengths, and a small difference is noticeable in the generated voltage.

It is possible that in the case stated, one armature was not in the exact center of the circle formed by the pole faces. If this be true, the machine with the eccentrically mounted armature would generate a lower voltage than the one with a truly centered armature. The reason is that the shortened air gaps around one-half of the armature circumference cannot compensate fully for the lengthened ones around the other half, because the excessive magnetic flux across the short gaps will increase the flux density in the corresponding magnet cores and this will choke down the increase in flux below the point necessary to compensate for the weakened poles diametrically opposite.

Cecil P. Poole.

Atlanta, Ga.

GAS POWER DEPARTMENT

Performance of Engine Operating on Coke-Oven Gas

The adaptability of the internal-combustion engine to the intermittent service required in many gas-pumping stations has led a number of illuminating-gas companies to install such engines in connection with rotary blowers or exhausters for handling large volumes of gas at low pressures. The low stand-by loss in conjunction with the high thermal efficiency of the gas engine results in a low cost for power, which is even more marked when some such fuel as coke-oven gas is available.

The People's Gas Light & Coke Co., of Chicago, has recently made an installation of this kind at its 110th St. pumping station. The equipment now consists of two 18x 24-in., tandem, double-acting, Buckeye gas engines, each driving a Piqua blower through a flexible coupling. A third unit of the same kind and size has been purchased and its installation is now under way.

The engines are of the standard Buckeye design, as illustrated in the Nov. 28, 1911, issue of POWER, except that the inlet valves are water cooled to assist in handling the high hydrogen gas which is obtained from a neighboring byproduct coke-oven plant of the Semet-Solvay Co.

A typical analysis of this gas after being purified is as follows: CO_2, 1.9; C_2H_4 and C_6H_6, 4; O, 1.6; H, 51.8; CH_4, 30.6; N, 5. The heat value ranges from 560 to 590 B.t.u. per cu.ft. This gas, after being properly

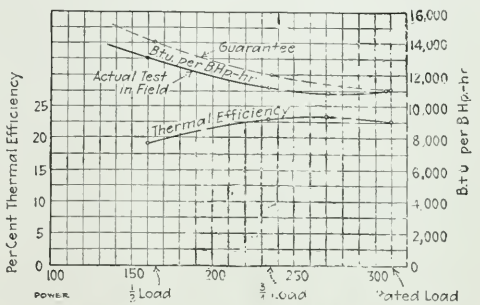


FIG. 2. RESULTS OF ECONOMY TEST

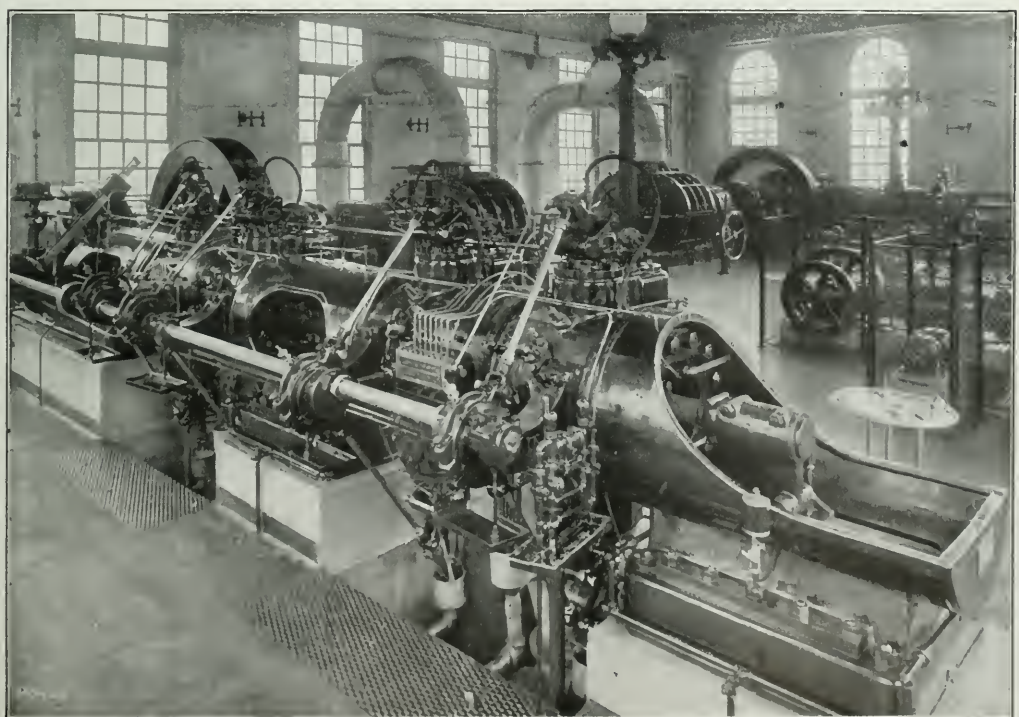


FIG. 1. ONE OF THE ENGINES AT THE PEOPLE'S GAS LIGHT & COKE CO.'S PLANT

enriched to meet the requirements of the Chicago ordinance as to candlepower and heat value, is pumped by the exhausters to the lighting mains.

Inasmuch as the quantity of gas pumped is variable, the engines are arranged to operate at any speed between 75 and 190 r.p.m. This is accomplished by a shifting weight in connection with the regular engine governor. Once set for the desired revolutions per minute this device holds the engine speed constant regardless of changes in the load caused by variations in the pressure against which the exhausters deliver the gas.

An economy and capacity test of these engines was made by the gas company's engineers on June 26 to 28, 1912. Results of the economy test are shown in Fig. 2. From this it will be noted that the highest thermal efficiency, 23.4 per cent., was attained at about seven-eighths load, although the curve is very flat from three-fourths to full load. The guaranteed heat consumption per brake horsepower-hour at various loads was as follows:

Load	Brake Horsepower	B.t.u. per Brake Horsepower-Hour
½	165	14,000
¾	236.5	12,000
Full	310	11,000

Reference to the curves will show that the actual performance was well within these figures.

Quality and Uniformity of Producer Gas

By Reginald Trautschold

The percentage of hydrogen in producer gas determines its richness, and upon the uniform quality of the gas depends largely the performance of the engine.

An insufficient supply of water vapor or steam will not only fail to furnish the requisite proportion of hydrogen, but the temperature of the fuel bed will become too intense. Too much water vapor, on the other hand, reduces the temperature of the fuel bed to the extent that it is unable to break up the steam into its component parts, so that there is again a scarcity of hydrogen in the delivered gas. The supply of water vapor then must depend upon the intensity of the heat in the producer and it was on this point that so many of the first installations of gas producers, where steam was obtained from some independent source and could not be readily proportioned to meet the exact requirements of the producer, proved unsatisfactory.

The necessity for uniform richness of the gas is now well recognized and, although careful tests have failed to establish any exact rule for the amount of water vapor required per pound of fuel consumed, the most experienced manufacturers of gas producers state that from 0.6 to 1 lb. of steam is required per pound of fuel consumed. This is very satisfactorily taken care of in certain types by causing the producer itself automatically to regulate and supply the water vapor carried through the bed of incandescent fuel. This can be done quite accurately as the heat of the fire bed is directly proportional to the amount of air supplied, which, in turn, is dependent upon the suction created by the engine and is thus proportional to the engine requirements of fuel. The supply of water vapor must then also be proportional to the fuel requirements of the engine and this is accomplished in several ways.

In the Smith producer, the fact that air at any given temperature is capable of carrying only a certain amount of water vapor in suspension (point of saturation) is made use of for properly proportioning the mixture of air and water vapor supplied to the producer. This proportion of air and water vapor not only maintains a producer fire at a satisfactory temperature, but also supplies the necessary hydrogen for a uniform mixture. The hot jacket water from the engine is utilized; being brought to a still higher temperature by heat reclaimed from the engine exhaust. The hot water is then discharged into a "saturator" so constructed that the air supply passes up through a bed of coke over which the heated jacket water is sprayed. The air supply for the producer, its volume proportional to the engine requirements for fuel, is passed up through the mass of coke and absorbs water vapor up to the point of saturation at the temperature of the mixture leaving the saturator. A thermostat in the path of the saturated and heated air, just before it enters the producer, regulates the amount of heated water discharged over the coke bed and thus maintains constant the temperature of the air supply and the amount of water vapor it is capable of carrying. The air supply being proportional to the heat of the fuel bed, the water supply is also correctly proportioned.

The Akerlund bituminous producer of the down-draft type regulates the supply of water vapor in a somewhat different manner. A water tank or vaporizer is situated within the producer shell surrounding the top of the ash bed, adjacent to the live-fuel bed. This tank is supplied with preheated water from the water-cooled top of the producer, the temperature of the supply being practically constant for any normal condition of fire bed. The heat from the fire converts this preheated water into vapor at a rate directly proportional to the temperature; this vapor rises and mixes with the air supply, which is also heated by circulating within the producer shell, and the temperature of which is likewise proportional to that of the fire bed. The heated air carries a quantity of water vapor which varies directly with the intensity of the heat of the fire and thus, as the air supply is proportional to the rate of gas production, a constant percentage of hydrogen is maintained in the delivered producer gas.

The Akerlund anthracite producer of the up-draft type uses a slightly different arrangement for maintaining the correct amount of hydrogen in the gas. In this producer, the top is also water cooled, forming a vaporizing chamber, and the air supply, after being heated by passing between the shell lining and the firebrick lining, circulates in the vaporizing chamber. After absorbing water vapor to the point of saturation, the heated air is drawn down inside the lining, and is delivered under the fire bed; it then passes up through the bed of incandescent fuel. The supply of water vapor is thus automatically regulated by the temperature, which is similarly regulated by the demands for gas so that the resulting gas is uniform in quality.

The Otto suction-gas producer employs practically the same method of regulating the supply of water vapor as is used in the anthracite-coal type of Akerlund producer. In fact, every successful producer makes provisions for regulating the vapor to conform to the rate of gasification. The apparent simplicity of the suction-gas producer will doubtless cause incorrectly proportioned and poorly de-

signed producers to continue to appear on the market. Therefore, it is still imperative for the purchaser to pay particular attention to the provisions for supplying a gas of uniform richness. This is a matter of importance that cannot be decided from records of economic production of power as indicated by tests that may have been conducted under unusually favorable conditions.

The early difficulties with producers depending for their operation upon a water-vapor supply that did not vary with the heat intensity of the fire bed, led to other means for keeping the temperature from becoming excessive and for supplying the elements necessary for the reduction of carbon dioxide to carbon monoxide. The most successful substitute was the exhaust gases from the engine. This is the method employed by the Tait producer and has given excellent results. The principle component of the exhaust gases from the engine, other than nitrogen, being carbon dioxide, the reduction taking place in the producer is very similar to that occurring when water vapor is used, the carbon dioxide combining with the incandescent carbon to form carbon monoxide, the inert nitrogen and the heat absorbed in reducing the carbon dioxide serving to keep down the temperature of the fire bed. The gas delivered is very uniform in quality and differs from that generated in a producer utilizing water vapor, by containing a somewhat smaller percentage of all the component gases other than marsh gas, of which there is a slight increase, and an increase in the percentage of nitrogen in the gas delivered from the producer.

High-Tension Ignition with Batteries

By A. L. Brennan, Jr.

The chief difference between high- and low-tension ignition is that the former system requires a secondary current in order that the resistance offered by the gap between the points of the spark plugs may be overcome. A high-tension system is more likely to short-circuit than low-tension and, therefore, it is important that well insulated wiring be used and that care be exercised to see that the insulation is not broken down by being repeatedly subjected to the elements, or to excessive chafing or vibration. The coils and batteries should be kept in a dry, clean place and if possible the wiring and spark plugs should also be protected.

Some troubles which point to faulty ignition, may be due to other causes. For instance, misfiring is often due to some derangement of the ignition system, but it may also be due to faulty carburetion or other causes.

As previously stated high-tension ignition may be divided into two parts: the primary and the secondary circuits. Therefore, if one will first become familiar with these parts and their corresponding relation, he will be able to distinguish and locate a trouble at once.

Consider a multi-cylinder engine that refuses to start, due to some fault of the ignition. First locate the seat of the trouble by turning the engine over to the several firing points with the switch in position (battery). If the motor is fitted with single-coil units each of which has a vibrator—it should be observed if each of these buzz; if so, the trouble is not in the primary circuit, comprising the batteries, contact points of vibrator, timer and battery connections or other primary wiring. From this the trouble is immediately traced to the secondary of the coil, high-tension wiring or spark plugs.

In order to see if a high-tension current is reaching the spark plugs, the motor should first be turned over to the firing point of No. 1 cylinder. Then throw out the switch and disconnect the secondary wire from the spark plug; again throw in the switch and, with the coil vibrating, hold the secondary wire terminal about 1/8 in. from the top of the plug. Observe if a good spark appears between the terminal and the plug. If one appears the trouble is in the plug, but if no spark appears the trouble is in the secondary windings of the coil, loose connection of the high-tension wires or the wrong unit is in circuit, that is, the motor may be on the firing point of another cylinder.

As to the spark gap mentioned, this may seem large, but it should be remembered that a spark which is efficient under the high pressures of the combustion chamber should easily jump a wider gap under atmospheric pressure. The spark-plug points should be clean and be set about the thickness of a dime apart.

Going back a step, suppose that when the engine is turned over, the vibrator fails to buzz. This would indicate trouble in the primary circuit, which might be due to weak or depleted batteries, timer points stuck, disconnected or broken wires, broken connections inside the coil, or to the vibrator contact points being stuck. On the other hand, if some, but not all, of the cylinders operate, it would indicate that the trouble was in the controlling features of the high-tension circuit. One or more of the following may be at fault: Tremblers on the coil stuck or out of adjustment; timer points not closing that circuit, or internal defects in the coil.

When adjusting coils always exert the least tension possible on the vibrators that is consistent with good results. Severe vibrator adjustments do not increase the efficiency of the motor but, on the other hand, cause additional demands upon the battery.

CORRESPONDENCE

Removing Piston Rings

In the Apr. 8 issue, A. L. Brennan, Jr., says, "It is advisable to remove the lowest ring first, for, otherwise, difficulty may be experienced while removing these rings last, as they would have a tendency to drop into the grooves of the other rings should the guide strips slip."

While this may be true with rings that are very limber, yet when the rings are stiff enough to offer much resistance to being pressed down in the groove, it is easier to take a ring over the empty grooves than over the other rings. When there are no strips of metal handy, a ring can be taken over grooves by keeping one side ahead of the other so the ring and groove are not parallel.

As to using emery cloth to remove carbon from rings and grooves: why is not a scraper to be preferred? A scraper can be made in a few minutes from an old file which will remove the carbon faster and as clean as anything.

Hawley L. Scott.

Bangs, Ohio.

REFRIGERATION DEPARTMENT

Running a Refrigerating Plant

By William L. Keil

If the refrigerating plant has been shut down for the winter months and is to be started up, quite some attention must be given to the various machinery and apparatus before a wheel is turned. After everything in the boiler room has been found in good condition the refrigerating machine itself should be inspected very carefully, especially the compressors. Other important parts of the plant that must be looked after are the water supply for the condensers, the condenser water pump and the storage tank.

When everything around the condensers is found ready for service, follow up the liquid line to the liquid tank and see how much ammonia the tank contains. If there is not enough to supply the system, additional ammonia must be pumped in after the machine has been started. When ready to start the machine, after its steam cylinder has been thoroughly heated, first start the water flowing over the condenser and through the jacket of the compressor if it has any, then having made sure that the discharge valves on the compressor and, as a matter of fact, all the valves in the ammonia-discharge line into the ammonia condenser are open, the machine may be started with the bypass open. After the machine has been running slowly for about one-half minute, and everything appears to be in good condition, shut the bypass valves and open the suction valves on the compressor very slowly and continue to run the machine at a moderate speed until the back-pressure gage indicates the pressure one likes to keep on the low-pressure side.

It is necessary to be very careful when opening the suction valve after the machine has been shut down for some time, even if only for over night, as liquid is likely to form in the suction pipe above it and if allowed to enter the compressor in large quantity may break it. Next open the main liquid valve slowly, then speed up the machine. Now watch the head pressure gage, which will soon indicate if the right amount of water is turned on. The head pressure should be kept between 120 and 180 lb. when the condenser water does not exceed 75 deg. F. If a well-water or a water-tower pump is used to supply the condenser with water, it should be started before the compressor. If the compressor has an oil system, the oil should be turned on next. The gages should be watched closely for quite some time.

It is most likely that some frost will come back at first which is harmless as long as it does not enter the compressor cylinder. If the plant has a brine system, all that is to be watched is the ammonia return from that tank. The direct system for a refrigerating plant requires somewhat more attention and a trip through the rooms being refrigerated should be made after an hour or two running of the machine and the temperature in each room noted. If the room is still too warm and the condition of the frost on the suction pipe permits, a little more ammonia should be turned on, if too cold, a little should be turned off, but in each case only a little at a time; otherwise the system will get out of gear. Look after all regulating valves; note where the return from each valve enters the main return. This knowledge is of great importance and may save many trips through the rooms. When freezing back too much, one can tell at a glance from which section the frost comes, by knowing the respective section return, which will be covered with so called live frost. Often, however, when the frost comes from one room very strongly, it may back up into all the other returns and then it is hard to tell by looking at them which is the one that is doing the damage, or if there are several returns giving trouble, which one freezes back the most.

By wetting the finger tips and touching each return, the one that sticks to the fingers most readily, is the one that should be turned off some. It is good practice to have marks of some kind on each expansion valve so placed that one can tell exactly how much was turned on or off.

If one wishes to obtain the best results in a refrigerating plant the machinery should be run regularly and evenly; otherwise things will go wrong. When excessive quantities of liquid come back to the compressor, the compressor piston-rod stuffing-box will start to leak. It is bad practice to tighten up on the stuffing-box glands as the rod contracts when cold but when the frost disappears the rod becomes hot and expands again so that the leak will disappear; otherwise the packing will burn when the rod expands. When the frost comes back to the machine on account of low steam pressure which causes the machine to slow down, the best thing to do is to shut the main liquid valve for a while or stop the machine, after having pumped the low-pressure side down to zero pressure, until the steam pressure rises again.

If a refrigerating machine is to be stopped for a little while only, and the valves in the compressors are in good order, the discharge stop valves may be left open but never the suction stop valves. This should be an engine-room rule.

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Regulations for Refrigerating Plants on Board Ship

A set of instructions for German steamship companies was recently published in the *Cold Storage and Ice Trade Journal*, credit for the original being given to *Eis und Kaelte Industrie*, of Vienna. These instructions may be of interest to the stationary engineer and in part are published herewith.

The steam cylinder of the refrigerating machine will be operated with steam coming from a reducing valve at a pressure of 100 lb. per sq.in. gage, but the cylinder must be able to withstand the full boiler pressure. (This means about double the pressure stated.)

The steel valves, together with their seats, must be

removable from the CO_2 compressor cylinder, and the latter made of steel also.

The condenser coils are to be of heavy continuous copper pipe. (As ammonia would at once attack copper pipes, ammonia machines are evidently not desired.)

The evaporator (usually a submerged coil cooling brine) is to be of full weight iron pipe, continuous welded.

Where there is more than one machine, the pipe connections must allow of putting in service any one machine or all of them. The brine-circulating pumps also must be cross-connected.

The steam-driven brine and cooling-water pumps should be of ample capacity, with pistons and valve casings made of bronze.

In large installations there should be three brine lines, and in small installations two, but with an extra return line from cargo rooms that are inaccessible during the voyage.

The brine mains, which should be run as straight as possible, are to be insulated with two layers of cork pipe covering, each layer 2 in. thick and encased in a conduit packed with hairfelt.

Provision must be made for regulating and shutting off each cooling room independent of any other room.

Each cooling room, but not the ice tank, is to have its own return brine line, with a valve at the brine cooler.

All brine-cooling pipes must withstand a test pressure of 85 lb. per sq.in.

Each cold-storage room is to have its own air cooler, the side wall of the inclosing housing to be removable.

In the case of direct-expansion piping, the coils should be connected in series, so that the refrigerating medium will circulate through the coldest rooms first. Through connections must be provided to enable any one room to be bypassed.

Ordinary refrigerators and water coolers should never be piped for direct expansion. (Use brine.)

Elements of Mechanical Refrigeration

On the evening of Apr. 19, A. G. Koenig read an interesting paper on the "Theory and Application of Mechanical Refrigeration," before the Institute of Operating Engineers, New York City. The paper was elementary in character, and was illustrated by a good selection of lantern slides. Due to lack of space, only extracts from the paper will be published.

If air is compressed in a cylinder with a movable piston, its temperature rises. If this compressed air is cooled, by passing it through a surface condenser, to the temperature of the cooling water, and then expanded in a second cylinder against the resistance of a movable piston, which allows the compressed air to do work, until its pressure is down to the original pressure, the temperature of the air will fall below its temperature before compression. This cold air is now in condition to cool anything with which it is brought in contact; in other words, it may be used to absorb heat.

If a pound of air at atmospheric pressure and 60 deg. F. is compressed to 75 lb., its temperature will rise to about 420 deg. F. If this compressed air is cooled down to 65 deg. F., and then allowed to do work in expanding to atmospheric pressure, the drop in temperature will be

$$65 - (-122) = 287 \text{ deg. F.}$$

and since the specific heat of air is 0.24, the heat withdrawn will be

$$287 \times 0.24 = 68.9 \text{ B.t.u.}$$

This heat the refrigerated air will re-absorb when heated to 65 deg. F.

If instead of air 1 lb. of ammonia vapor at 20 lb. pressure and 5 deg. F. had been compressed to 120 lb. pressure, its temperature would rise to about 200 deg. F. This compressed vapor can then be cooled to 65 deg. F., but as it will also liquify at this temperature and pressure its latent heat as well as its sensible heat will be removed. The heat rejected by the ammonia vapor in liquifying is equal to the difference in temperature multiplied by the specific heat of the ammonia, 0.532, plus the latent heat at the condenser pressure, 515 B.t.u. The heat would then be

$$(220 - 65) \times 0.532 + 515 = 586.8 \text{ B.t.u.}$$

Due to mechanical difficulties, a second cylinder for expansion is never used, but the liquid is injected into the refrigerator through a pressure-reducing valve. In passing through this valve the liquid is cooled down to the evaporation temperature in the refrigerator at the expense of some of its latent heat, so that the available refrigerating effect per pound of liquid circulated is reduced to about 480 B.t.u.

It is thus apparent that air is not a good refrigerant, and in producing cold we depend mostly on substances changing their state of matter from a solid to a liquid, or from a liquid to a vapor. The so called freezing mixtures are good illustrations of the change from a solid to a liquid.

If a solid substance is dissolved in a liquid, or if two solid substances, as salt and ice, for example, are mixed to form a liquid, a certain amount of heat is required to bring about the change from solid to liquid. If the vessel in which the substances are mixed is well insulated, so that no heat is supplied from any outside source, the necessary heat must be drawn from the mixture itself, and its own temperature lowered in consequence. By mixing two parts of ice with one part of common salt, as in the old-fashioned ice-cream freezer, a temperature of 5 deg. F. can be obtained. If three parts of ice are mixed with four parts of potash, a temperature as low as —51 deg. F. is obtained. Even without the use of ice, low temperatures may be produced by mixing certain chemicals. This is a rather expensive way of producing "cold," and for the same reason, freezing mixtures are not used; so that, for commercial operation we are limited largely to a liquid changing to a vapor or gas.

Evidently for best results in refrigeration, it is desirous to hasten the process as much as possible, and, therefore, a liquid having a low boiling point, combined with a high latent heat of evaporation is selected. Several liquids have this combination, and those most commonly used are ammonia, carbon dioxide and sulphur dioxide. The boiling and condensing points and the latent heat of the above substances are as follows:

	Boiling and condensing point at atmos. press. deg. F	Latent heat, B.t.u. per lb atmos. press.	Cu ft. of vapor per lb., atmos. press.
Ammonia	—27	588	18
Carbon Dioxide	—112	177	0 878
Sulphur Dioxide.....	+14	168	5 25

At the proper working pressures the boiling and condensing points and the latent heats are for the above substances:

	Boiling and condensing points, deg. F.	Gage press. lb.	Latent heat, B.t.u. per lb.	Cu.ft. of av. vapor per lb.
Ammonia	0	15	570	9.2
Carbon Dioxide	40	278	127	0.29
Sulphur Dioxide	14	0	168	5.25
Ammonia	90	166	488	1.63
Carbon Dioxide	86	1065	19.28	0.147
Sulphur Dioxide	86	51.5	151.5	1.27

If these volatile liquids were cheap enough, all the apparatus required for the purpose of refrigerating would be a tank or drum in which to receive the liquid, connected with a regulating valve to a sufficiently large pipe coil, in which the liquid is allowed to boil and evaporate, absorbing heat from the surrounding air or brine, as the case may be; but since ammonia, or any of the other refrigerants are too expensive for such a process, it is necessary to recover them and put them back into liquid form, so that they may be used over and over again. For the recovery of these liquids, there are, in the case of ammonia, two different methods, mechanical compression by a compressor, and compression by the use of heat in an absorption system. The author outlined the working of these two systems, but as the methods of operation of both have been recently explained in these columns, there will be no need for a repetition.

Unit of Refrigeration

The unit adopted to measure refrigeration is the heat required to melt 1 lb. of ice, which is 144 B.t.u. The unit for a ton (2000 lb.) of ice-melting capacity is, therefore,

$$2000 \times 144 = 288{,}000 \ B.t.u.$$

The commercial tonnage capacity is the refrigerating effect expressed in tons of ice-melting capacity produced by a machines in 24 hr., when running continuously under a standard set of conditions. These conditions are for an ammonia-refrigerating system 15 lb. evaporator or suction pressure, equal to a temperature of 0 deg. F., and 170 lb. condenser pressure, equal to a temperature of 91 deg. F. The above unit of refrigeration reduces to 200 B.t.u. per min. A few examples were given by the author to illustrate the practical use of the unit of refrigeration, and these may be of general interest.

Estimating Refrigeration in Brewery

How many tons of refrigeration are required to cool to 40 deg. F. 300 bbl. of wort having a specific heat of 0.95 and a temperature of 85 deg. F.? The cooling to be done in three hours.

Taking the weight of 1 bbl. of wort at 265 lb. gives

$$300 \times 265 = 79{,}500 \ lb.$$

of wort to cool. The difference in temperature is 85 — 40 = 45 deg. and the specific heat 0.95. Then

$$79{,}500 \times 0.95 \times 45 = 3{,}398{,}625 \ B.t.u.$$

which must be withdrawn from the wort.* This requires

$$\frac{3{,}398{,}625}{288{,}000} = 11.8$$

tons of refrigeration in 24 hr. But the cooling is to be done in three hours, therefore,

$$11.8 \times \tfrac{24}{3} = 94.4 \ tons$$

of refrigeration, which would be the size of the machine.

Packing-House Example

What size machine is required for a packing house killing 500 heads of beef per day, average weight of beef being 800 lb., and storage room required?

*The weight of a barrel of wort has been assumed as 265 lb. in this example. For greater accuracy, the specific weight of the wort should be taken into consideration.

Assuming 10 sq.ft. per head and a height of 20 ft., the size of chill room required would be 50 × 100 × 20 ft. high. The exposed wall surface would be

$$100 \times 20 \times 2 = 4000$$
$$50 \times 20 \times 2 = 2000$$
$$100 \times 50 = 5000$$

Total 11,000 sq.ft.

Assuming that 4 B.t.u. pass through every square foot per 24 hr. for every degree difference in temperature between 35 deg. inside and 90 deg. outside, the gain in heat would be

$$(90 - 35) \times 4 = 220 \ B.t.u.$$
$$220 \times 11{,}000 = 2{,}420{,}000 \ B.t.u. \ per \ 24 \ hr.$$
$$500 \times 800 \times 0.8 \times 65 = 20{,}800{,}000 \ B.t.u. \ per \ 24 \ hr.$$
$$20{,}800{,}000 + 2{,}420{,}000 = 23{,}220{,}000$$
$$\frac{23{,}220{,}000}{288{,}000} = 80.6 \ tons \ per \ 24 \ hr.$$

Keeping the beef in a cold-storage room 30x100x20 ft. high equals 8200 sq.ft., the gain in heat would be

$$8200 \times 4 \times 55 = 1{,}804{,}000 \ B.t.u.$$

Allowing a loss of 20 per cent. for opening of doors, makes a total of 2,164,800 B.t.u. Then

$$\frac{2{,}164{,}800}{288{,}000} = 7.5 \ tons$$

Cooling of fat, three tanks of water and extra refrigerators for small stock requires an additional 17.5 tons which makes a total of

$$80.6 + 7.5 + 17.5 = 105.6 \ tons$$

of refrigeration.

Cooling Water per Ton of Refrigeration

From the definition of a unit of refrigeration, the refrigerating system must absorb 288,000 B.t.u. per 24 hr., or 200 B.t.u. per min. This amount of heat, plus the heat of compression amounting to about 10 per cent., is delivered to the condenser and must be carried off by the cooling water.

If the temperature of the cooling water delivered to the condenser is 75 deg. F. and of the water leaving 85 deg. F., each pound of water flowing over the condenser will have absorbed 10 B.t.u., and since a gallon of water weighs approximately 8.3 lb., each gallon of water will carry off

$$10 \times 8.3 = 83 \ B.t.u.$$

For each ton of refrigeration 200 + 20 B.t.u. are to be removed per minute, so that

$$\frac{220}{83} = 2.7 \ gal.$$

of cooling water per min. per ton of refrigeration will be required.

A more accurate method for calculating the amount of cooling water is as follows: Assume, for example, that the condensing temperature of the ammonia is 90 deg. F. its latent heat at that temperature 489 B.t.u. and that the gas goes to the condenser at 240 deg. F. The gas would be superheated 150 deg. Then

$$150 \times 0.532 = 79.8 \ B.t.u.$$
$$489 + 79.8 = 568.8 \ B.t.u.$$

per lb. of ammonia. But 0.4 lb. of ammonia are required per minute per ton of refrigeration, therefore,

$$0.4 \times 568.8 = 227.52 \ B.t.u.$$

must be absorbed, and

$$\frac{227.52}{83} = 2.74 \ gal.$$

per minute per ton of refrigeration would be required.

EDITORIALS

Consulting and Operating Engineers

Managing a business is much like playing a game wherein the value of each card must be carefully weighed. Each man in the business has a certain value and must be placed in such a position and given such influence as is compatible with his training and capacity. The duty of a manager is to pick his men so that he can apportion to each a sphere of action commensurate with his ability and to obtain a system that will work as a harmonious whole. To attain this end the spheres of action of all the men must touch and to some extent overlap.

In all industrial plants where machinery is used to turn out the product, managers have often been hard pressed to bridge over the gulf between the commercial department and the force that has charge of the machinery equipment.

Managers often find themselves at a disadvantage, when it comes to supervising the power plant, for want of the necessary training. Therefore, the sphere of action of the business man neither touches nor overlaps that of the operating man. The province of the technically trained engineer is to bridge over this gap.

The technically trained engineer studies the laws of nature underlying the principles of operation of all kinds of machinery, and takes advantage of all opportunities to observe and take a hand in their actual running. He does this to learn the difficulties encountered and to be able to apply to a useful purpose the special knowledge that he has been fortunate enough to acquire. It is not his desire to take the place of the engineer or encroach upon his work, for their spheres of work are entirely different, and if either goes beyond his limits he is at once beset with all kinds of anxieties and troubles.

It is for these and other good reasons that the supervision of operation of all large power houses and industrial plants by technically trained engineers has become desirable. Wherever a plant or group of plants is large enough to warrant the expense, trained engineers are employed. Where the size of the plant does not warrant the expense it is advisable to retain the services of a consulting engineer who has made that particular brand of engineering or manufacture his life work. In this way his expense can be divided between a number of manufacturers.

The ice making and refrigerating industry, although it has ample use for them, has not employed technical men to any great extent. The reasons are that there are but few technically trained men available, that most of the owners and managers of such plants do not appreciate the value of such services and that the operating men often do not seem to be aware of the benefits to be derived from a free coöperation with consulting refrigerating engineers. Competition has made economy of plant operation a prime factor, and lack of technical help or advice is directly responsible for many failures of owners to realize the profits which otherwise would be theirs.

Operating engineers sometimes labor under the false impression that they are injuring their prestige if they do not pretend to know as much as anyone else on all phases of their work. When such an engineer gets into trouble he looks to the manufacturer of the machinery he runs to help him out, but it is hardly fair to expect a firm to employ a sufficient number of skilled men to take care of and watch the operation of every plant they have equipped. It must be said in defense of the engineer that owners and managers have contributed to this false attitude because they do not appreciate the difficulties of the situation and expect an unreasonable amount of knowledge and experience from their engineers.

The work of the consulting engineer then is entirely different from that of the operating engineer. Each one has a certain allotted work to perform and whenever he transgresses too seriously on work outside of his province there is trouble ahead.

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Right Men in the Right Place

Success comes to the men who fight on where others give up and allow matters to take their course. Some engineers do not know the meaning of defeat, but go on overcoming obstacles instead of sitting down and saying, "It is of no use, it cannot be done." One power plant in a Western state, that survived the ravages of wind and water, was kept in operation with a shutdown of only about fourteen hours, because those in charge made a stand and fought.

The high wind which preceded the flood completely demolished a brick, high-tension booster station and tore down the high-tension lines. The interurban trolley service was disabled until repairs could be made or temporary arrangements made. The latter were adopted and electrical energy was supplied from a five hundred and fifty-volt feeder, twenty-six miles long. Then light-weight cars were run to keep the drop in voltage as low as possible. It seems simple now, but how many managers would have adopted this method of keeping the trolley line in operation?

This problem was hardly solved before the power plant was menaced by the rising river water. Although the engine-room floor had been built four feet above the highest water level recorded, before the flood subsided the water level had risen three feet above the floor of the generator floor. But, owing to the ability of those in charge to grasp the emergency situation, the plant was undamaged when the flood subsided.

Here was a case requiring decision and prompt action if the power-plant machinery was not to be damaged by water. How was it to be done? Could the water from the rapidly rising river be prevented from flooding the basement, auxiliary machinery, the generator floor and main units?

The general manager and engineer decided that the basement walls had to be protected from the pressure of

the water to prevent them from being forced in. As there was but little time, about one hundred men were put to work to build a wall of sand bags around the building to deflect the river current, and by hard work the sand-bag dike was kept at a greater height than the rapidly rising water.

As another precaution a temporary brick wall was built in the interior of the turbine room at either end, and the doors were sealed with sand bags. This was to prevent the water leaking through the sand-bag dike, getting into the room.

Then the water in the basement had to be removed, and there were no spare pumps. Did they throw up their hands and say "It cannot be done?" Hardly. They disconnected the centrifugal-circulating pumps and used them, and the exciter units were run to light the plant while the work was going on. When there was time to make different arrangements, reciprocating pumps were procured, and connecting the circulating pump to the condensers the plant was started with but a short shutdown.

Here is a typical case of what the right men in the right place can do. Had the men in charge of this plant been of the "give it up" caliber it is probable that extensive repairs would have been necessary to put the plant in operating condition, in addition to the inconvenience and loss the necessary shutdown would have occasioned.

Troubles of the Trouble Man

What is more aggravating, when retained by a plant to make improvements and reduce costs and just about to accomplish something worth while, than to be denied that satisfaction by an order to cease work until the management gets ready to have it continued? If you have never had this experience as an expert engineer, you can appreciate the feeling by recollecting your boyhood days, when father called you to hoe potatoes just as you were finishing the best kite you ever made.

Putting an uneconomical and rapidly deteriorating, though, perhaps, comparatively new, plant into economical and stable condition is difficult enough without being hampered by a management that is suspicious when it ought to be grateful. Under the most favorable conditions you are likely to offend someone who is "in right." It may be the chief engineer, master mechanic, manager or perhaps a consulting engineer friend of the president. You do not know until the inevitable "clash" occurs, and that happens when you condemn a steam main which is a veritable water leg, and which may have been designed by any of the aforementioned individuals. It may be that you make six boilers do the work for which the master mechanic or chief engineer used twelve. At any rate you are "no good" and the "in right" individual immediately seeks to convince the management that you are all you should not be. Too often he succeeds.

As an example of pitiable ignorance or contemptible obstinacy we recall an expert engineer who, in the schedule which he left with the company as a guide for the most economical operation of its plant, specified three pints of oil per day of twelve hours for each engine. The plant normally operated twelve hours per day and the schedule was made out on that basis. One day afterward a long letter came complaining bitterly because the specified three pints of oil was not enough and that a few engines had been nearly ruined.

Investigation revealed that the plant was operating eighteen hours per day. As the expert engineer tells it, the chief engineer of that plant did not consider his intelligence insulted when a new schedule arrived which specified the oil consumption for each hour's operation over the twelve-hour day.

Co-operation in Power-Plant Work

The everyday work in large power plants is usually performed without waste of time or effort because such work must be done in an orderly manner. Each knows what his day's work includes, hence the men need no special instructions so long as their work does not depart from the regular routine. But in emergencies or when extensive or unusual repairs are to be made, confusion and loss of time often follow an order for such work, because the one who issues the order does not sufficiently coöperate with those that are to do the work.

For instance, consider changes in the steam main of a large plant that requires a change over from one steam header to the other. One "fitter" and a helper are sometimes put on this job, which is long and hard, while, perhaps, at the same time, other fitters and helpers are sent to make insignificant repairs that one man could complete in a few hours. Should something happen—and something usually does—to delay the men working on the steam main it would undoubtedly mean overtime work for them and perhaps hinder the plant's operation.

There should be a general "getting together" prior to doing such work. Let the man who is to direct the work give full particulars to the one who is actually to do the work. The latter should then see to it that he has the required number of assistants and that each of them has his particular part of the work laid out for him.

When a repair job is to be done or new work commenced, the man in charge should outline to his helpers the manner of procedure so that they may have a good idea of what next is to come, as the job progresses.

Unpreparedness

Some large manufacturing establishments along the Atlantic coast and up the tidewater waterways were caught napping recently, when the outgoing tide dropped the water level to the lowest point in thirty years. The tide went out so far that the ends of the condenser circulating-water pipes were uncovered, depriving the engines of condenser service, which is necessary to enable them to carry their loads.

The situation was indeed serious in some plants because the tide remained out for a considerable time. Those plants not prepared for such emergencies paid dear for their unpreparedness.

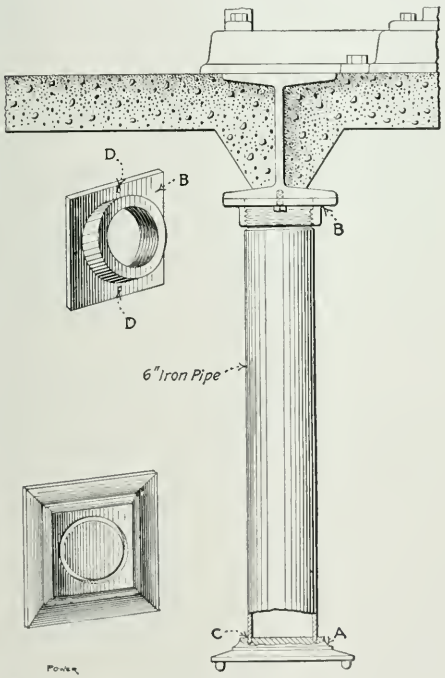
The same is true of plants where units of one kind or another are crippled, not necessarily seriously, but enough to make problematical their continuity of service. The required repairs are not made until these several minor weaknesses produce a "general debility" as it were, of the entire plant. That is another kind of unforgivable unpreparedness.

READERS WITH SOMETHING TO SAY

Adjustable Support for Generator Foundation

The sketch shows a steel post that was used to strengthen the cement floor on which a new generator set was to be installed. Five of these were made and set under the I-beams that supported the cement floor.

The posts were of 6-in. iron pipe cut to length and threaded on one end. Plates *A* and *B* were of cast iron, *B* being threaded for the pipe or post, while the plate *A*



Details of Adjustable Support for Generator Foundation

was cast with a groove *C*, which was of the thickness and diameter of the pipe. Before placing the post under the I-beam, plate *B* was screwed on the threaded end of the pipe as far as it could be turned by hand; the post was then set in the groove in plate *A* and holes were drilled and tapped in the I-beam. Also holes were drilled in plate *B* at *DD* to correspond with the holes in the I-beam. The post was then set so that the holes in the beam and those in plate *B* came in line; bolts were then inserted, raising the post up and leaving a clearance of ¼ in. between the bottom of the groove in plate *A* and the end of the pipe. To bring the pipe and plate together a pair of chain tongs were used to unscrew the pipe a few threads from the top plate, thus making the post tight against the floor and I-beam.

J. B. Linker.

Charlotte, N. C.

Condenser Repairs

One of the valve stems on the lower deck of a bucket condenser worked loose and dropped through the opening in the valve seat. As it was impossible to get the stud without removing the valve seat, which there was not time to do, a new stem was the best solution of the trouble.

A common bolt was taken of suitable size and length, and a piece of pipe cut to fit over the bolt and long enough

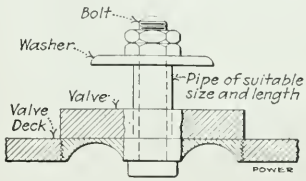


Fig. 1. Stud as Repaired

to allow the valve to raise as high as it had originally. The pipe served as the shoulder on the original valve stem, so that the valve guard could be screwed down against it. The illustration, Fig. 1, shows the stud as it was repaired. A large washer on the valve guard against which the pipe bushing and nut came, permitted securing the bolt in a firm position.

In Fig. 2 is shown how a hand pump was connected to

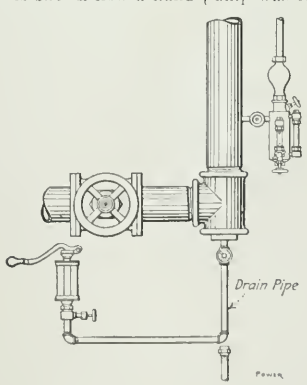


Fig. 2. Piping of Hand Oil Pump

the steam pipe through which the cylinder was lubricated until repairs could be made to the lubricator connection.

The trouble was caused by the breaking of the ¼-in. iron-pipe connection from the lubricator at the main steam pipe. A hand oil pump was taken from the main

engine and, after disconnecting the drain pipe at the union, was attached as shown and oil pumped to the cylinder until the engine could be shut down at the end of the week.

Water to a barometric condenser was supplied through a 5-in. pipe which extended perpendicularly from the pump through the engine-room roof, ran horizontally 4 ft., and then perpendicularly to the condenser head. As

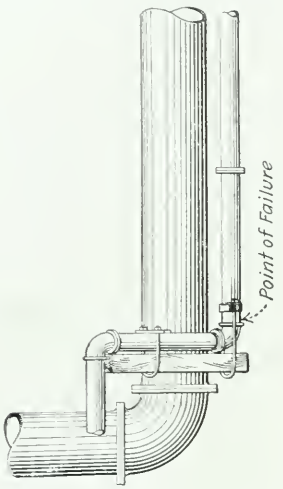


FIG. 3. HOW THE PIPE JOINT WAS HELD TOGETHER

the pipe line was not properly connected, one night it pulled apart at the ell, as shown in Fig. 3, the pipe having been screwed in not more than three threads. As the day load was heavier than the night load it was impossible to spare the condenser and it was decided to repair the leak that night to tide over until such time as a permanent job could be made.

Some pieces of 1x1¼-in. iron were secured long enough to form a U-bend around the wooden supporting member and to pass through a cross-piece on top. A second clamp was used as shown on the vertical pipes.

When the clamps were ready a piece of 4x4-in. wood, of sufficient length to reach from the horizontal pipe, but beyond the second vertical pipe, was placed as shown. This was held by one of the U-clamps, the outer U-clamp passing through a band clamp on the vertical pipe, as shown. The nuts on the U-bends were tightened which drew the vertical pipe into the tee and supported it in place. Then pine plugs were driven in around the pipe and followed up with lead, thus stopping the leak.

JOHN J. RAMSEY.

Wellington, Kan.

Better Attention, Better Service

The engineer having a license should be absolutely in charge of the steam plant. Examiners of engineers, when they visit a plant, should ask the owner or manager who is held responsible for the plant. If the master mechanic is, find out whether or not he has a license. If not, he should be required to have one, or not have anything to do with the plant. As the law is now, one gets a license and the state holds him responsible for any accident in the plant. Should any occur, it would probably deprive his family of a livelihood, and still he has no jurisdiction over the plant. I do not want to have the license law enforced as a farce.

If engineers want to progress, they should receive more questions regarding breakdowns, and how to make repairs without calling in outside help, which often means a loss of time to their employers. The engineer should be granted a license on the amount and kind of experience he has had. In looking over the field, it will be found that many engineers have received their license by being tutored in engineering schools which have sprung up "like mushrooms in the night."

How many engineers enter their engine rooms on a Monday morning, thinking, "Now, what can I do to help my employer in every way, not only in saving in the power plant, but by giving him the greatest possible speed to get the greatest production?" I do not think that many of them give it a thought that one or two revolutions lost on the engine means a great loss to the employer.

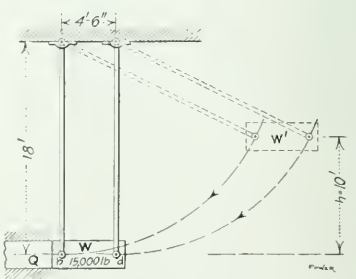
When I was a young man, having charge of a cotton-mill plant, I never thought of leaving the plant Saturday night, unless I went into the cloth room to find how much the production was for that week. It showed to my employer that I was interested in the entire plant. I never had to ask for an increase in pay. It was always coming. If engineers would devote more attention to making their plants paying investments, many small plants, which are now idle, would be operating.

GEORGE H. DIMAN.

Lawrence, Mass.

Best Form of Link

A mass of iron, weighing 15,000 lb., suspended by four links, each 18 ft. long, like *AB* and *CD*, as shown in the accompanying sketch, is lifted by a magnet to the position *W'* through a vertical height of $h = 10$ ft. After being raised to this height, the magnet releases the



weight and, upon arriving at the lowest point of its travel *W*, the weight strikes a resisting mass *Q*.

Assuming that the weight moves a distance of not more than 2 in. after impact, and neglecting friction of the center pins, what section of link would be best suited to withstand the stresses due to the centrifugal force of the weight and the impact of the weight itself?

Philadelphia, Penn. S. N. BOWMAN.

[Answers from readers would be appreciated.—EDITOR.]

QUESTIONS BEFORE THE HOUSE

The Allis-Chalmers Engine

Referring to the article under the above title, in the Jan. 21 issue, signed by Richard H. Rice, I would state that I was the engineer in charge of the Corliss engine department of the Allis-Chalmers Co. during the time that their new engine was designed, built, tested and placed on the market. I have no apologies to offer anyone for the work done while I was in charge of that department.

The engine is not an exact copy of the Rice-Sargeant engine as stated. The Allis-Chalmers Co. has built double-ported valves for many years. The steam valves are located no nearer the cylinder than they have been for over 30 years on all engines with valves in the corner of the cylinder. The exhaust valves have been placed higher than in the old engine to reduce the clearance. The same thing has been done by several builders of Corliss engines. The Allis-Chalmers Co. has been building engines with both steam and exhaust valves in the heads for many years, which design gives less clearance than is possible with the design for which Mr. Rice claims his former company was the pioneer.

I wish to call attention to Mr. Rice's statement that the use of the wristplate motion limits the cutoff to from 0.4 to 0.5 stroke and would ask Mr. Rice what the wristplate has to do with the cutoff. The Allis-Chalmers Co. has built double-eccentric engines both with and without steam wristplates, according to the purchaser's desire, and has been doing that for many years. The first man to apply separate eccentrics to actuate the steam and exhaust valves on Corliss engines was the late William E. Crane, while he was operating engines at Waterbury, Conn. The Green engine, which was built before the Rice-Sargeant engine, in the same shops, had two eccentrics and no wristplate.

Referring to the comments on the new Allis-Chalmers Co. governor, I would state that I believe it to be the most powerful, sensitive and nearest fool-proof of anything that has been designed up to date. The advertising matter sent out by the Rice-Sargeant Co. would indicate that they had abandoned the Rites inertia governor. The picture of their new governor looks very much like the governor on the Allis-Chalmers Co.'s engine in the Metropolitan Life Insurance Co.'s building in New York City. On the acceptance test, the regulation of the Allis-Chalmers Co.'s engine was far superior to the Rice-Sargeant engines, which were equipped with the Rites inertia governor. An examination of the Allis-Chalmers governor and the Rites inertia governor, mentioned in Mr. Rice's letter, will convince any engineer that the former has less parts; therefore less complications and on account of its being entirely inclosed can be flooded with oil which greatly prolongs its useful life.

Ample provisions have been made to take care of the expansion between the cylinder, frames and foundations. I note that Mr. Rice refrains from saying anything about the Allis-Chalmers Co.'s frame, self-adjusting main bearing, oil guards and other points that are strictly uptodate but concedes *their* engine was designed 19 years ago. Finally, would say that I am not with the Allis-Chalmers Co., am under no obligations to them except to wish the company the success it deserves.

R. D. Tomlinson.

Danbury, Conn.

Mr. Flannery's Feed-Water Heater

Some statements in Mr. Flannery's letter concerning the trouble with his feed-water heater I do not understand. He says that the heater is much too large and, in proof of this, says that when he runs the pump fast he gets a temperature of 200 deg.; but when running slow only gets a temperature of 190 deg., and he also says that if the heater was smaller, the water would move faster and he would get a higher temperature.

I fail to see just how he accounts for this. I believe that the reason is that he does not get enough steam to heat the water over 190 deg., but when running the inefficient "steam eating" pump at higher speeds, he gets more steam in the heater, and, consequently, heats the water to a higher temperature. The slower the water moves through an open heater, the hotter it will get, up to 212 deg.

He also states that he has 4 ft. of water below the suction pipe and only 14 in. above it that is available for use if the supply is interrupted. If he will examine the inside of his heater, I think he will find a hood covering the suction opening so that he can pump out the greater part of that 4 ft. of water, or, if not, there is, or should be, a bypass from the lower part of the chamber to the suction pipe. Further on, he states that when the filter gets dirty he has trouble in regulating the water supply. This, I consider, a good proof of the efficiency of the filter. If it gets clogged up in a short time, it shows that it is effective in removing the foreign matter, and his trouble lies in that he does not clean it often enough. I think it would be much more desirable to clean the deposit out of the heater than out of the boiler.

His trouble seems to be due chiefly to lack of steam to heat the water; possibly only a small part of the steam goes to the heater, the rest being used for other purposes. I have operated some ten or twelve different heaters and, although I found some that would not heat the water as hot as they should, there was usually some reason other than the design to account for it.

J. C. Hawkins.

Hyattsville, Md.

While rebuilding a steam plant under my supervision, it was decided to install an open feed-water heater. The one selected was of the through type, i.e., all of the exhaust entered the side and passed out of the top. The feed water entered the top, falling into a cast-iron pan which overflowed into a set of cast-iron trays, from which

it fell to the filtering material, through this to a chamber in the bottom of the heater. The hot-water outlet was at the lowest point of the hot-water chamber.

We set the heater so that the bottom of the hot-water chamber was one foot above the pump suction. Mr. Flannery can overcome part of his trouble by raising his heater and putting in a bypass from the lowest point to his suction line, keeping the piping always below the outlet. This would give unfiltered water, but it would be better in an emergency than no water at all.

In operating our heater, we soon found that a two weeks' run choked the trays with scale, besides lining the interior with scale ¾ in. thick. The trays "froze" in the guides so firmly it was very hard to remove them for cleaning. To overcome this, we made strap-iron hangers to fit 2-in. pipe and long enough to slip into the grooves in place of the trays. These hangers were so made that pieces of pipe cut as long as the heater was deep inside, would be 1½ in. apart in the row and the rows staggered when placed in position. There were six rows and two hangers for each row. It was a quick job to remove, clean and replace these pipes.

We had much trouble using coke for a filter material as small particles washed through and filled up the outlet pipe. Coarse marsh hay, or "swamp grass" as some call it, makes the cleanest and quickest filter material we have ever used.

While Mr. Flannery's heater is too large for his boiler capacity, I do not believe this should materially affect the temperature of the water if the heater was arranged differently. With us the temperature never varied, no matter how much or how little water was being passed. I believe the cause of the drop in temperature is due to a large quantity of water being held ahead of the filter in the coldest part of the heater, where it is subject to excessive radiation before it is filtered. If the water was held directly under the trays, where it would be in the hottest part of the heater, it would stay hot. Naturally, the faster the water travels through Mr. Flannery's type of heater, the hotter it will be, as it is subject to that much less radiation.

G. Anderson.

Cresco, Iowa.

Operating Costs of Hydraulic vs. Electric Elevators

The writer was much interested in Mr. Waldron's contribution on the above subject, in the Jan. 28 issue. If we could save coal in heating buildings by first using the steam for elevator service, and thus taking the exhaust for heating, nearly all buildings would soon be equipped with elevators, running up and down automatically, to reduce the coal bill.

Mr. Waldron must have made some mistake. Perhaps the winter the electric elevators were used was more severe than the previous one when those of the hydraulic type were used. Perhaps serious leaks that allowed the escape of many B.t.u. may have occurred during the second year. Faulty traps, scaled boilers, scaled feed-water heater or many other things might have caused the increase in the coal consumption over what it was when the steam was used for the elevator pumps before being admitted to the heating system.

If there are steam boilers on the premises, it will prove cheaper to use the steam for the elevators and the exhaust for heating than it will to use the steam for heating and buy electric current for the elevators, unless the electric power is furnished very cheaply. On the other hand, a given amount of steam will furnish more heat to the rooms if used direct, than if first used for some other purpose.

From Mr. Waldron's letter, I conclude that the central station was carrying all the lighting load and all the power load, excepting that for the elevators. If this is so, it would seem reasonable to either give the central stations the elevator load also, or take all the load away from them. Mr. Waldron does not say whether or not the boilers were shut down in the summer, after the new elevators were installed; but if they were not, and low-pressure steam were necessary the year round, it seems difficult to see how the central station ever got hold of that building in the first place.

John Bailey.

Milwaukee, Wis.

Available CO_2 Percentages

In his letter "Available CO_2 Percentages," in the Apr. 15 issue, A. Pohlman brings up a question that probably has occurred to many engineers. The only purpose of this letter is to call attention to an error in an otherwise excellent article.

As Mr. Pohlman states, perfect combustion of pure carbon in air would give 21 per cent. CO_2 and 79 per cent. nitrogen and this would require 11.6 lb. of air per pound of carbon or, at ordinary temperature and pressure, 152.7 cu.ft. If, however, the fuel contained only 70 per cent. carbon and the remaining 30 per cent. were ash, the gas analysis for perfect combustion would still be 21 per cent. CO_2 and 79 per cent. nitrogen, but the amount of air required would be only

$$0.70 \times 11.6 \text{ lb.} = 8.12 \text{ lb.}$$

of air, or 106.8 cu.ft.

Most fuels, however, contain hydrogen in varying quantities and this is what does affect the percentage of CO_2 that can be obtained even with the best firing, as this hydrogen combines with the oxygen of the air to form water, which in the furnace gases exists as superheated steam, but which, when a sample is drawn off for analysis in the Orsat apparatus, condenses and disappears, as far as that analysis is concerned.

For instance, take an extreme case. Pittsburgh natural gas, contains by volume, methane (CH_4), 89.3 per cent.; ethane (C_2H_6), 8.5 per cent., and nitrogen (N), 2.2 per cent., or by weight carbon (C), 73.4 per cent.; hydrogen (H), 23.1 per cent.; nitrogen (N), 3.5 per cent.

With perfect combustion this gas gives an analysis of 12 per cent. CO_2 and 88 per cent. nitrogen. Fuel oil also shows a low maximum possible percentage of CO_2, 15.7 per cent.; nitrogen, 84.3 per cent., for an oil containing 87.8 per cent. carbon and 12.2 per cent. hydrogen by weight.

Most coals, particularly those sold in the East, show much higher maximum possible percentages of CO_2, as the available hydrogen, i.e., hydrogen content after subtracting that already combined with the oxygen in the coal and existing as water of constitution, is much less

and give maximum percentages of between 18 and 19 per cent. CO_2, the remainder being nitrogen. The writer has obtained results checking the above figures in practice when the air supply happened to be just right to give perfect combustion.

The surest guide to the working of any furnace is to analyze the flue gases for carbon dioxide, oxygen and carbon monoxide, as by this method complete information is obtained and nothing is left to guesswork. The magnitude of the unnecessary losses can then be easily ascertained as these are in direct proportion to the ratio of the unnecessary or excess air above that required for combustion to the amount necessary to give complete combustion with the coal and the temperature and also to the ratio of the carbon monoxide to the sum of the carbon dioxide and carbon monoxide. The first of these, the excess air loss, does not bear a direct relation to the percentage of CO_2 but increases at an increasing rate as percentage of CO_2 decreases. For instance, with 14 per cent. CO_2, a decrease of 1 per cent. CO_2 and a corresponding increase in oxygen would indicate an increase in air excess from 36 to 47 per cent., whereas at 7 per cent. CO_2, a decrease of ½ per cent. in CO_2 means an increase in air excess of from 180 to 202 per cent., and a decrease of 1 per cent. in CO_2 an increase in air excess from 180 to 226 per cent.

The excess air percentage can be calculated for any gas analysis from the formula.

$$\textit{Percentage excess air} = 100 \times \frac{0.265\ \textit{percentage nitrogen} - \textit{per cent. oxygen}}{\textit{percentage oxygen}}$$

The carbon-monoxide loss, due to the escape of unburned gases up the stack, depends, as stated before, on the ratio of the percentage of carbon monoxide to the sum of the percentages of carbon monoxide and carbon dioxide. Thus it will be seen that, when the percentage of CO_2 is low, small percentages of carbon monoxide may mean a serious loss, whereas, if the percentage of CO_2 is high, such a small fraction of the total carbon is escaping unburned that the loss is unimportant. Usually, however, any percentage of carbon monoxide that can be unmistakably detected by an Orsat, say, 0.3 to 0.5 per cent., is more than should occur and a sufficiently thinner fire should be carried to do away with it, as the loss due to the necessary increase in air excess will usually be much less than that due to the carbon monoxide.

In water-tube boilers with horizontal tubes and vertical baffles the presence of carbon monoxide can be detected at once by watching the cracks in the lower part of the front baffle through the soot blow-holes in the second pass, as blue flames appear there as soon as carbon monoxide is formed, and after a little practice the percentage present can be estimated within reasonable limits from the length and thickness of the flame.

The relative importance of these two losses depends largely on the flue temperature. Where this is low, as in boilers, a comparatively large increase in percentage of air excess will cause less loss than a small increase in carbon monoxide while in high-temperature work, such as in iron and glass furnaces, the losses due to air excess are much more serious than those due to unburned gases, on account of the much greater effect they have in lowering the temperature of the furnace.

In taking samples of flue gas it is important, if it is desired to check the work of the fireman, to see that the sampling tube is so arranged that it draws from a well mixed body of gas coming from the fire and undiluted by air. A boiler setting in good condition should not increase the air excess in the flue gases more than 30 to 50 per cent. between the middle of the first pass, and the flue neck, with the boiler running at or about rated capacity, and if it is found impossible to get gas analysis containing more than 8 to 10 per cent. CO_2 when the fire has been put in good shape and the sampling connections, etc., are known to be tight, the setting should be carefully gone over for air leaks and repaired. Then the maximum economical percentage of CO_2 to carry will be that at which, with a level fuel bed of the proper thickness for the draft, traces of carbon monoxide begin to show. Always care must be taken that, in endeavoring to obtain a good gas analysis, the fire is not so thickened that the boiler is nearly banked and the capacity seriously reduced, as this has been known to occur.

H. D. Fisher.

Newton Highlands, Mass.

Care of High-Vacuum Apparatus

Referring to the article under the above title, in the Dec. 31 issue, I would offer the following comment:

Relative to the condenser log for a 2000-kw. turbine, dated July 13, 1911, the most important figure appears to have been overlooked, the barometer reading. Without this reading, a fair criticism is impossible, and I can only assume that the vacuum readings given refer to a 30-in. barometer reading. Where were the air-pump discharge and hotwell-line readings observed? It is not stated that a separate hotwell pump handled the condensate, so the assumption is that a suction-valveless air pump handles both the air and the condensate. If so, one would expect the condensate temperature to lie somewhere between the temperature of the circulating-water inlet and outlet, whereas the figures indicate that the condensate kept within 1 deg. of the steam temperature and the nearest it approached the circulating-water discharge temperature was 4 deg. above. At 9 o'clock p.m., it was actually 11 deg. hotter than the discharged circulating water.

We all endeavor to withdraw the condensate at as high a temperature as practicable, commensurate with reasonable proportions for air pumps, so one is inclined to wonder what special means were adopted in this instance, inasmuch as the air pumps do not appear to have been too well proportioned in the way of displacement efficiency. The log states that at 9:30 p.m., the air-pump plunger-rod glands were leaking. From a comparison of the steam temperatures given with the vacuum logged, this leak would appear to have been more excessive at 6:30 p.m.

At 6:30 p.m., the load was 900 kw.; steam temperature 90 deg., which corresponds to a vacuum of 28.58 in., whereas the vacuum logged was 28.4 in., leaving a vacuum of 0.18 in. to be accounted for by the pressure of air.

At 9:30 p.m., the load was 1865 kw.; steam temperature 101 deg., corresponding to 28.011 in. vacuum. The vacuum logged was 27.9 in., leaving a vacuum of 0.111 in. loss, due to air in the condenser.

This letter is written in an honest attempt to understand this part of the published article.

Goodmayes, Eng. W. Vincent Teeeby.

Putting New Valve Stems in Corliss Engine

In the Jan. 28 issue, H. W. Lee asks for information in regard to putting in Corliss valve stems. Although he does not say so, I suppose he will get them from the engine builder, in which case all that he will have to do is cut the keyways, as it will not be necessary to dismantle the valve-gear.

To take the old stems out, remove the packing from the stuffing-boxes, take off the back bonnets and pull the valves back with an eye-bolt, then draw out the keys and push the stems back into the valve chamber. If the new stems are of proper dimensions, all that is necessary is to dress down the T-head of the stem, which is left a little large so that it can be made a tight fit in the slot in the end of the valve. One of the most simple ways of cutting a keyway in a valve stem is the following:

The new stems are turned up in the machine shop and then put in the engine. The valve is put in and the bell crank fitted on. The valve is then set with the proper amount of lead and is held from turning by inserting a piece of cardboard between the valve and the bonnet, which is drawn up tight. The wristplate is then put in its central position and the valve rod screwed in about one or two threads. To mark the stem for the keyway in the bell crank, a combination square with a center head is placed on the end of the stem and bell crank and a line is drawn through the center of the keyway and center of the stem; then two other lines are drawn parallel to the center line to mark the width for the keyways.

The ends of the valve stems and the valve bonnets should be marked with a center punch to identify them. The stems are then taken to the shop and three lines drawn on the shaft with a keyseat square, to correspond to the lines drawn on the end of the stems. A line is drawn to locate the depth of the keyseat or keyway. The length of the keyway is then measured and a center punch mark made at this point on the center line. The stems are then taken to the drill press and a hole of the required depth drilled at the end of the keyways. Then the stems are ready to be put in the shaper, and the keyway cut to the proper width and depth.

When a planer or shaper cannot be reached, the keyway may be cut with a cape chisel, making it a little narrower than the required width and dressing it out with a file to the exact dimension. There are other ways of locating the keyways, but this, I think, is the best.

After the new stems are in, one should check up the valve setting, because it may have been changed while the repairs were being made. After getting the engine in operation, apply the indicator and make such minor adjustments as may be required.

J. C. Hawkins.

Hyattsville, Md.

Having renewed the stems in a large Corliss engine, I will state my method, hoping it will assist Mr. Lee.

The first proceeding is to remove the back bonnets of the valves. Considering first the steam valves, hook up the valve, the stem of which is to be renewed, and move the valve-gear in the direction it takes when running until the central marks on the wristplate, hub and trunnion are line and line; now make a light scratch mark on the back end of the valve and chamber. (It will be best to make this mark where it will not be confused with the marks showing the working edge of the port and valve.)

Next remove the valve from the chamber and, after drawing the key, the old stem may be removed through the valve chamber, which saves the work of removing the front bonnet or yoke.

The new stem is now inserted in the same manner and the bell crank, carrying the latch-block and dashpot connection, slipped on the new stem. With the block and hook engaged again, move the wristplate to the central position; insert the valve in the chamber, placing the T-head on the valve stem in the slot in the end of the valve. Turn the valve and stem until the scratch marks previously made are line and line. A scriber may now be inserted in the keyway in the bell crank and the position of the keyway marked on the new stem, which is now taken out and the keyway cut, after which the gear is again assembled, the key driven in, the valve hooked up and the wristplate brought again to the central position, when the scratch marks on the end of the valve and chamber should be line and line, if the keyway has been properly cut. If they are not line and line, change the valve rod enough to make them so.

If the valves are heavy, it will probably be easier to remove the front bonnets in taking out the stems.

The same method is followed with each of the valves.

When bringing the wristplate to the central position, it will be well to bring it in the same direction each time it is centered for the separate valves, as this insures the lost motion in the valve-gear being taken up alike and lessens the possibility of having to change the valve rod.

I changed four stems on a Corliss engine in this manner and, in only one instance, was it necessary to make any change in the valve rods, as the setting of the valves was not altered.

C. B. Hudson.

Malden, Mass.

What Is a Bleeder?

In Inquiries of General Interest, for Mar. 18, 1913, was the one "What is a Bleeder?" Although the answer given is correct, it may not be the one sought. Another type of bleeder is a valve that opens into the condenser, and is used mainly in marine power plants to reduce the steam pressure on the boilers, thus preventing them from blowing off. The writer has seen them used only on surface condensers.

There is one fault with this bleeder. If the fireman or stoker knows where it is, but does not know when it should be used, he might do some damage. The writer was in the engine room of a steamer when a fireman came in and picked up a T-wrench (the valve was below the grating) and started to open the bleeder, and being asked what he intended to do, he stated that he wished to reduce the steam pressure as it was at the blowing-off point. The boat at this time was tied up at the dock and all pumps stopped (that is, circulating pumps).

After explaining the bleeder and when it should be used, I started the circulating pump, and cautioned him never to open the bleeder while the pump was stopped, as he might get a dangerous pressure in the condenser.

New Bedford, Mass. L. J. Olliver.

INQUIRIES OF GENERAL INTEREST

Leaking Piston—When steam leaks past the piston how can it be told whether new rings will be enough or whether the cylinder should also be rebored?

A. P.

If the cylinder is not seriously scratched or cut, and careful calipering at various points shows no greater variation in the cylinder diameter than $^3/_{64}$ in. (for a moderate size cylinder), the cylinder need not be rebored.

Lead Boiler Manhole Gaskets—What is the objection to the use of a lead manhole gasket below the water-line of a boiler?

W. M.

Because such gaskets, being inelastic, are permanently compressed by expansion and contraction. Thus leaks are likely to develop unexpectedly and without giving warning of their existence until the water in the boiler has fallen to a dangerousiy low level.

Boiler Feeding Under Pressure—What is meant by the term "under pressure" used in connection with water delivered to feed boilers from an elevated tank?

H. V. W.

When feed water is delivered to a boiler by tank or reservoir pressure which is sufficient to overcome the boiler pressure without using a pump, injector or other feeder, the boiler is said to be fed "under pressure," i.e., only the pressure it has as delivered to the plant.

Impregnating Wire Coils—Explain the process of impregnating the coils of a 15-hp. motor for underground use?

H. V. W.

Such coils are impregnated with a waterproofing compound (mainly rubber) forced in under pressure by first exhausting the air from the coil. The coil is put into a sealed iron tank from which the air is exhausted until a high vacuum is obtained. The compound is then introduced and a high pressure again admitted to the tank interior and the impregnating compound is forced into all the interstices of the coil.

Connecting Ammeter—On which side of a circuit should an ammeter be placed, i.e., on the positive or the negative?

H. R. L.

In connection with a compound-wound generator, which is run in parallel with another machine, the ammeter should always be placed on the opposite side from that in which the series field and equalizer connection are inserted. The equalizer connection is always made between the brush and the series field, but the latter may be on either the positive or the negative side. The object of placing the meter on the opposite side from the equalizer is to prevent it from recording currents from other machines.

Lightest Gasoline Engine—What is the lightest engine per horsepower that has been built and how does it compare with other engines?

C. J. J.

The seven-cylinder Gnome, an aëroplane engine, is the lightest, weighing only 3½ lb. per hp. This refers to the engine proper and does not include the weight of the necessary auxiliary plant as gasoline tank, radiator, etc. Automobile engines usually weigh 18 to 24 lb. per hp., but this weight includes a flywheel, whereas the Gnome has none. A two-stroke-cycle marine Diesel engine of Nurnberg type, weighs 50 lb. per hp. Stationary oil engines weigh up to about 270 lb. per hp.

Algae in Water—What causes a green moss-like substance to grow in a water tank, and how can it be prevented? The tank is open to the atmosphere and and water is pumped from a deep well, and is used for laundry and drinking purposes.

A. A. G.

The growth referred to is of vegetable origin and of many natures, but all generally classified as algae. They have no harmful effect on water for any purpose; the principal objection to their presence in water is their tendency to clog piping and plumbing. Algae are far more likely to occur in water drawn from deep wells than from surface waters. The best way to discourage the growth is to keep the water in tanks from which light is excluded.

Coal Consumption—We have three 150-hp. water-tube boilers used for heating and drying and carrying 50-lb. pressure. Is not 2000 tons of coal per year too much to be burning?

O. W. G.

The horsepower rating of the boilers is no criterion of the amount of coal burned. The only way to prove the economy is to determine the amount of water evaporated in relation to the amount of coal burned. This must be done by an evaporative test. If the boilers are found to be evaporating 7 to 10 lb. of water per pound of coal from and at 212 deg. F., or the equivalent, they may be regarded as doing fairly well. If not, the conditions of the firing, of the boiler settings and of the boilers themselves should be examined and improved where needful.

CO_2 Specific Heat—What is the specific heat of carbonic-acid gas?

J. B.

This is not a constant quantity, but varies with the pressure and volume. The figures obtained by different investigators do not agree. The latest edition of "Experimental Engineering," by Carpenter & Diederichs, gives the values by G. Upton, who also plotted curves of average values, according to which the mean specific heats at constant pressure and at constant volume are as follows:

Deg. F.	Constant Pressure	Constant Volume
0	0.2	0.155
400	0.215	0.170
1000	0.235	0.190
2000	0.260	0.215
2500	0.270	0.225

Properties of Steam—Is there any rule for calculating the temperature and relative volume of steam from a given pressure?

E. S.

Regnault, the French physicist, made numerous and careful experiments to determine the relations of pressure, temperature and volume of steam and a number of able scientists have been over the same ground since. Very complicated empirical formulas have been constructed of the properties of steam and these have been corrected and recorrected graphically. Many textbooks on steam give these formulas. The ones now regarded as most exact are to be found in Marks and Davis "Steam Tables and Diagrams." The use of the formulas is so cumbersome that it is universally the custom to use tables of these properties instead of carrying out independent calculations.

Condensing or Noncondensing Operation—We have a 16x36-in. Corliss engine driving a 150-kw. generator. It operates under light load 18 hr. and normal load 6 hr. Would it probably pay to operate condensing?

J. S. H.

Ordinarily it does not pay to install condensing equipment in a plant containing only one engine and that a small one, for the exhaust steam can likely all be used for heating feed water. During the peak load about 20 per cent. would be saved if the engine exhausted into a 26-in. vacuum. The light load during three-fourths of the time calls for early cutoff and a condenser might effect no saving during this time, as the cylinder cooling through a great range of expansion in a single cylinder will bring about two much initial condensation. Reducing the initial pressure during this time and with a vacuum of 26 in., there might be 20 per cent. saving in steam consumption. Whether or not it will pay to install condensing equipment will depend very largely on the cost of cooling water in any given locality. The net economy will be determined by estimating from the cost of the equipment, interest on the investment, depreciation, and the cost of operation. Against this place saving in decreased fuel consumption and reduced cost of labor (if any). If there is a difference in favor of condensing it will pay to make the change unless there is a need of the exhaust steam for heating purposes. In the latter case there is seldom any advantage in operating condensing.

ENGINEERS' STUDY COURSE

Principles of Combustion—III

Combining Weights of Elements

Whenever a chemical action, such as combustion, takes place, the elements or compounds always combine in fixed proportions by weight. Because of this fact we are able to use Col. 3 in Table I, which gives the combining weights of the various elements. Whenever two or more elements combine they do so either in direct proportion to the numbers shown in Col. 3 or in some multiple of those numbers. The exact manner in which they combine is shown by the formulas in Col. 4. Thus, when carbon combines with other elements it always combines in weights of 12 or some multiple of 12, such as 24, 36, 48, etc., depending on the formula. When oxygen combines it does so in weights of 16 or multiples of 16. And so with all other elements, they combine according to their combining weights or atomic weights as the chemist usually calls them.

Combustion of Carbon

Carbon has two ways of combining with oxygen. One is called complete combustion and the other incomplete combustion. Whether combustion is complete or incomplete depends upon conditions. If sufficient air is supplied to every particle of the carbon, combustion will be complete; if not, some of the carbon will be only partially burned.

Taking up incomplete combustion first, the formula in Col. 4 is

$$C + O = CO$$

This means that the carbon combines with the oxygen in the proportion by weight of 12 to 16, because those are the combining weights of the two elements. This reduces to 1 to $1\frac{1}{3}$. Hence, for every pound of carbon incompletely burned $1\frac{1}{3}$ lb. of oxygen are required. If 27 lb. of carbon were incompletely burned the amount of oxygen used would be 36 lb., because the proportion of 27 to 36 is the same as 12 to 16 or 1 to $1\frac{1}{3}$. The figuring is just the same for all other quantities of carbon no matter whether the amount is a fraction of an ounce or thousands of tons.

The product of the incomplete combustion of carbon is a gas called carbon monoxide and its chemical symbol is CO.

The name monoxide is one of those built-up words from mono, meaning one or one part, and oxide, meaning the chemical union of oxygen with some other substance. Thus, carbon monoxide means one part of oxygen united with carbon. When the number of parts of the other element is not stated it is always taken as one. Hence, the exact meaning of carbon monoxide is one part of carbon united with one part of oxygen.

To calculate the amount in pounds of the CO formed it is only necessary to add the weight of the carbon burned and the weight of the oxygen required according to the formula; the result is the weight of the carbon monoxide. What the volume of this gas is depends upon the temperature as has been explained.

Thus, if 5 lb. of carbon are incompletely burned the weight of CO formed is

Weight of carbon	5 lb.
Weight of oxygen required $5 \times 1\frac{1}{3}$	$6\frac{2}{3}$ lb
Weight of carbon monoxide formed	$11\frac{2}{3}$ lb.

This carbon monoxide is a combustible gas and if supplied with air so that it can unite with the required amount of oxygen it will burn when heated to its temperature of ignition. Its formula is

$$CO + O = CO_2$$

TABLE I. COMBUSTION DATA

Col. 1 Name of Element	Col. 2 Symbol of Element	Col. 3 Combining Weight	Col. 4 Combustion Formula	Col. 5 Compound Formed	Col. 6 Heat Liberated B.t.u. per lb. of Combustible	Col. 7 Pounds of Oxygen Required per lb. of Combustible	Col. 8 Pounds of Air Required per lb. of Combustible
Carbon	C	12	$C + O = CO$	Carbon Monoxide (Incomplete Combustion)	4,450	$1\frac{1}{3}$	5.76
			$C + 2O = CO_2$	Carbon Dioxide (Complete Combustion)	14,600	$2\frac{2}{3}$	11.52
			$CO + O = CO_2$	Carbon Dioxide	4,350*	$\frac{4}{7}$	2.47
Hydrogen	H	1	$2H + O = H_2O$	Water	62,000	8	34.56
Sulphur	S	32	$S + 2O = SO_2$	Sulphur Dioxide			
			$S + 3O = SO_3$	Sulphur Trioxide			
Oxygen	O	16					
Nitrogen	N	14					

*This figure is correct and replaces the 10,150 given in the Apr. 22 issue.

This means that the CO or carbon monoxide combines with oxygen in the proportion of

$$C + O \text{ to } O$$
$$12 + 16 \text{ to } 16 = 28 \text{ to } 16$$

or 1 to $\frac{16}{28}$, which equals 1 to $\frac{4}{7}$. Thus, for every pound of CO burned $\frac{4}{7}$ of a pound of oxygen is required.

The product of the combustion of CO is a gas called carbon dioxide, which has the chemical symbol CO_2.

The name dioxide is built up in a manner similar to monoxide, the prefix di meaning two or two parts. Thus, carbon dioxide means one part of carbon combined with two parts of oxygen. By "parts" it must be remembered we mean "chemical parts," i.e., combining weights as shown in Table I and explained before. The weight of CO_2 formed by the combustion of CO is found by adding the weight of CO burned to the amount of oxygen required according to the formula. Thus, if 6 lb. of CO were burned to CO_2 the weight of CO_2 formed would be

Weight of CO burned	6 lb.
Weight of oxygen required 6×$\frac{4}{7}$	$3\frac{3}{7}$ lb.
Weight of carbon dioxide formed	$9\frac{3}{7}$ lb

If sufficient air is supplied in the first place so that each particle of carbon can unite with all the oxygen it desires, complete combustion results, the formula for which follows:

$$C + 2\,O = CO_2$$

This means that the carbon unites with the oxygen in the proportion of

$$C + 2\,O = CO_2$$
$$12 + 2\,(16) = 44$$

producing $\frac{44}{12} = 3\frac{2}{3}$ lb. of CO_2 for every pound of carbon burned. Every pound of carbon when completely burned requires $\frac{32}{12} = 2\frac{2}{3}$ lb. of oxygen.

Combustion of Hydrogen

When carbon is burned, part of it may be burned completely to form CO_2 and the rest may be only partly burned to form CO. This is not true of hydrogen. The hydrogen either burns completely or not at all. Thus, if not enough air is supplied for a given quantity of hydrogen, part of the hydrogen (enough to use up all the oxygen in the air supplied) burns completely and the balance does not burn at all.

The formula for the combustion of hydrogen is

$$2\,H + O = H_2O$$

According to Table I, Col. 3, the combining weight of hydrogen is 1, that of oxygen 16, the same as in all other cases. Thus, substituting in the formula, we have

$$2\,H + O = H_2O$$
$$2\,(1) + 16 = 18$$

It requires then $\frac{16}{2} = 8$ lb. of oxygen for the complete combustion of every pound of hydrogen burned, and the weight of the product formed is $\frac{18}{2} = 9$ lb.

The product formed by the combustion of hydrogen is water (H_2O) in the shape of highly superheated steam. This steam can be condensed just the same as steam made directly from water can be condensed back into water again.

Sulphur burns with oxygen and forms SO_2 in much the same way that carbon burns to form CO_2. The formula is

$$S + 2\,O = SO_2$$
$$32 + 2\,(16) = 64$$

From this it will be seen that

$$\frac{32}{32} = 1\ lb.$$

of oxygen is required for the combustion of every pound of sulphur and that

$$\frac{64}{32} = 2\ lb.$$

of sulphur dioxide are formed.

Sulphur will also combine according to this formula

$$S + 3\,O = SO_3$$

Here ½ lb. more of oxygen is required for combustion. These products (SO_2 and SO_3) easily combine with water and form sulphurous and sulphuric acid as follows:

$$SO_2 + H_2O = H_2SO_3$$
$$SO_3 + H_2O = H_2SO_4$$

These acids strongly attack iron and hence do injury to flues and chimneys made of that material.

As pointed out previously, the heat value of sulphur is so low and the percentage of sulphur found in the average grade of coal is so small that we can easily afford to neglect it completely in our calculations.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Bad case of an engine running away (from the owner) happened near Pittsburgh recently. Footprints in the snow showed that the operators had loaded the 600-lb. engine into a wagon and skipped with it. Must be trying to prejudice the owner against the isolated plant.

⁂

You should eat more onions, advises the Department of Agriculture, thus reducing the cost of eats. It will also tell you where you can locate a supply cheap. It needs no Burns to find the whereabouts of the average healthy onion; it speaks for itself. A hunk of rye bread, a rosy-cheeked Bermuda, a Ponderosa and a can of suds are nourishing some of our hardest-working citizens.

⁂

Next time you are under the knife, insist on getting old Doc. Greene's automatic metal rivet, and take no other. These rivets can be applied to the edges of the wound, and instead of the old stitching, can be laced or unlaced to suit the convenience—of the doctor. May be a shop kink in the use of the stay-bolt, if Doc. finds his way to experiment with it.

⁂

"Gas Review" has an article written by Clam on gasoline engines. Can our old French friend, Colonel De Paty du Clam, have forsaken the nine gods of war to follow a peaceful trade? Us technical papers will spend any amount of money to get the best there is. Anybody here know Clam?

⁂

Folks to home have always reckoned that the Vice-President was merely a bench-warmer, just couldn't get into the game unless the Big Pitcher was taken out of the box. Not so with T. Riley Marshall; he's one lively little man, and a rooter from Rootersville. "Baseball diamond dirt is clean dirt," says T. Riley, "and that's more than a Democrat can say for all the diamonds in America."

⁂

"When one gets to love work, his life is a happy one," says Ruskin. Are you ready for the question? Those in favor—(delegate wakes up in time to shout "i"; thinks he's voting for the 8-hr. law). Contrary minded: NO! The "noes" have it by 976 to 1. Move we adjourn!

⁂

The proposed tariff may help a bit. On meats it calls for a 50 per cent. reduction; dead poultry (no time limit given) 30, and prunes 50; very little was squeezed out of lemons, and butter and cheese are still going strong; beans and cream and pickles and honey come down some; also mushrooms and cider and grapes and pork; also oranges and tallow; starch stays pretty stiff. Buckwheat and shoe machinery go on the free list. Some of these foodstuffs are high yet to our way of thinking, but you can't handle a tariff bill too carefully, even if it never passes.

⁂

The fillums now include steam as a fitting subject for both interest and education. A photoplay has been written around the early struggles of Watt and Stephenson. Undoubtedly there is a future for popular science in the movies.

⁂

"It is easier to live on $15 a week than on $15,000 a year," says a writer. Without the Missouri test, this is bunk. Will some power-plant fireman kindly step up on the platform and tell the audience what he thinks about it? This way, please.

⁂

"When excessive water ram occurs in riveted-steel pipe, the riveted joints open up slightly by a momentary stretching of the rivets, or yield in other parts, within the elastic limit, and allow water to escape from the joints. If the excess pressure is not too great and too long continued, the pipe comes back to its original size, and is as tight as before."—New England Water Works Association Proceedings, Vol. 25, page 39.

Why not use these "elastic" rivets in horizontal return tubular-boiler construction and thus make every boiler its own safety valve?

Power Matters in Textile Mills*

By F. W. Dean

SYNOPSIS—The turbine vs. the reciprocating engine, fire-tube vs. water-tube boilers and purchased power vs. a plant at the mill.

The question constantly arises as to whether it is best to purchase turbines or reciprocating engines. This must depend upon the original costs, the space occupied, the relative economies when new, the maintenance of economy after operation begins, the reliability and the repairs.

Initial Cost and Floor Space

In Table 1 are given prices to be expected at this time of several units of each kind of prime mover. These are for sizes in which the kilowatts are real outputs at 80 per cent. power factor.

TABLE 1. COSTS OF AND SPACE OCCUPIED BY VARIOUS SIZES OF RECIPROCATING ENGINES AND TURBINES WITH CONDENSING APPARATUS AND EXCITERS, ALL ERECTED, INCLUDING FOUNDATIONS

(Capacities given in real outputs)

Capacities Kw	Horizontal 4-Valve Engines	Horizontal Turbines	Space Occupied Engines	Space Occupied Turbines
500	$22,700	$12,250	18x26 ft.	14x6 ft.
1000	40,200	17,900	24x30 ft.	14x8 ft.
1500	62,200	23,800	26x35 ft.	19x9 ft.
2000	76,100	30,500	28x37 ft.	21x9 ft.

From this table it is evident that the comparison is wholly in favor of the turbine. The relative economies to be expected from the two types are given in Table 2.

TABLE 2. STEAM CONSUMED PER KILOWATT-HOUR, PRESSURE 150 LB.

Capacities, Kw.	Engine: Saturated Steam Guaranteed per Kw-hr., lb	Engine: Superheat 100 Deg. F Guaranteed per Kw-hr., lb.	Turbine: Superheat 100 Deg. F Guaranteed per Kw-hr., lb.
500	18.67	16.8	17.7
1000	18.80	16.9	18.0
1500	18.80	16.9	16.8
2000	18.93	17.0	16.6
		Vacuum 26 in.	Vacuum 28 in.

Apparently there is little to choose in the economy of one type of prime mover over the other. It is said that an experimental turbine of 10,000 kw. capacity has been tested that used 12.95 lb. of steam, superheated 100 deg. F., per kilowatt-hour and there is every probability that the turbine will be improved.

Maintenance

Concerning the maintenance of economy it is well known that the best reciprocating engines, with either Corliss gridiron or poppet valves, maintain their economy for years, and that the blades or buckets of turbines have been eroded by the steam as it passes over them. There are instances of this erosion being sufficient to make the replacement of blades necessary, as there was a great falling off in economy. Blades have eroded so rapidly in some cases that it has been necessary to replace a set at a cost of several thousand dollars in five years. It appears to depend largely upon the material of which the blades are made, and improvements in this respect have been made and are being made. Turbines are not stripping blades nowadays as they did a few years ago. Repairs in other respects than this are slight, much less, in fact, than with piston engines, and in many cases no blade replacements have been needed.

*Abstract of a paper read before the National Association of Cotton Manufacturers, Boston, Apr. 24.

High Vacuum for Engines Desirable

Turbines are always provided with condensing apparatus of sufficient capacity to give a vacuum of at least 28 in. It is assumed by all operating engineers that a vacuum of anywhere from 23 to 27 in. is desirable for a reciprocating engine, the reason being that there is more economy in obtaining feed water from the condenser discharge with the higher temperature, due to a poor vacuum, than there is with the lower, due to a high vacuum. This belief may have had some truth in the days when the air and feed pumps were worked from the main engine, and when separate steam-driven auxiliaries were not used, the exhausts of which are now used for heating feed water, and when also other means of heating boiler feed were not known or used.

At the present time this idea is a mistake. It will always be found that a condensing engine with a high vacuum is more economical than one with a low vacuum, not only in steam consumption, but in coal consumption, especially when the feed water is not taken from the condenser discharge. The other belief seems to be world wide, and apparently has been handed down from the distant past.

The turbine is usually given the benefit of superheated steam, but it appears to be claimed both by turbine and engine builders that about 1 per cent. of steam is saved for each 10 deg. F. of superheat.

It should not be overlooked that the most economical steam engine is the noncondensing engine, the exhaust steam of which is utilized, and in this application the turbine shares. It is not as economical when noncondensing as the engine. In other words, it produces more exhaust steam for the same power, but if this is all utilized it makes no difference. The turbine also shares with the compound engine the opportunity to draw steam for manufacturing purposes between the expansion stages.

There is an important application of the turbine that is not shared by the piston engine. This is the exhaust-steam turbine. While the economy of the piston engine would be improved by a high vacuum, recently low-pressure turbines have been placed between the low-pressure cylinder and the condenser, simultaneously with an improvement in the vacuum. The turbine lends itself to this application better than a piston engine, for to obtain a similar result with the engine, an enormous low-pressure cylinder would be required. Low-pressure turbines can operate with the collected exhausts of any number, kind and size of engines, and high economy is sure to result. Moreover, the mixed-pressure turbine will be automatically supplied with live steam as the supply of exhaust steam diminishes or fails.

Steam turbines practically cannot be applied to direct-current generators unless they are geared so that the generator speed is reduced to diminish commutator difficulties. While turbines for direct-current generators are made, the contemplation of a turbine presupposes, ordinarily, alternating current. Further, the adoption of a turbine carries with it the use of electricity in driving shafting or machines directly, that is, in groups or individually as the case demands.

Belt, Rope and Electric Drives

If a mill permits the application of a piston engine with simple straight belt or rope drives, this is a more efficient method of driving than by electricity. If the drives are indirect the friction load may be as much as 40 to 50 per cent., and electricity is the more efficient.

There are advantages in electrical driving, among which may be mentioned smaller space occupied by the prime mover, absence of a belt tower, head shafts, pulleys and belts or ropes, any amount of subdivision of drives with the resulting opportunity of shutting down groups of machinery, the application of motors to separate machines, and the measurement of the power which a motor gives out. It is said that efficient variable-speed motors will soon be in the market, and these will be a convenience.

In the above advantages that of an increased output by electrically driven machinery is not included. It is possible to understand how machines driven by electric motors can go either faster or steadier than those driven by belts. If there has been an increase in product in any case it must have been due to removable defects of the original drive. It is evident that this must be so in an extended group drive, for there is little or no diminution in the number of belts used. It would, therefore, only be in individual drives that the increase would exist and here there is no reason why the belt cannot do whatever the motor can.

In general, the advantages of electricity are such that it is probable it will be used universally in the early future for driving textile mills. One reason, not thus far mentioned, is that it permits a central steam plant to be used under all circumstances, and this adds to efficiency and minimum charges of all kinds, especially in an overgrown mill having several steam plants. A further consideration of the matter leads to the inevitable conclusion that prime movers in textile mills will be steam turbines operated by superheated steam of rather high pressure. The economy of turbines is increasing and is likely to surpass that of piston engines.

In bad-water districts the fact that turbines use no oil in the working steam is a great advantage, for with surface condensers the pure water from the condensed steam can be used in the boilers and thus avoid the boiler troubles that come from bad water.

The Boiler Plant

Fire-tube boilers, either vertical or horizontal return tubular, are cheaper to build, are more economical, more easily cleaned, and safer than water-tube boilers. To the writer's knowledge no horizontal return-tubular boiler built with butt joints has exploded, nor has any straight or conical-shell vertical boiler with such joints exploded. There have been many disastrous explosions of water-tube boilers.

Water-tube boilers have tubes expanded into drums, and have in these drums structures in unstable form likely to change shape with variations in temperature. This causes the plates to bend back and forth in the weakest place, thus causing a likelihood of rupture in the same manner as in the case of shells with lap joints. Water-tube boilers have from two to four drums, and each one of these is more likely to explode from the effects of distortion than the well balanced shell of a horizontal or vertical fire-tube boiler.

The economy of the fire-tube type is greater than of the water-tube, because the tubes can be kept cleaner, because they are as clean on the fire sides when old as when new, because they do not short-circuit, and because they are not partially covered up by baffle tiles. Another important reason for greater economy is that water-tube boilers have several doors and clean-out holes in the brickwork, and these leak air, especially after the boilers have been in use some time. This cools the gases, reduces the economy of the boiler and also that of the economizer if one is used.

Concerning the safety of fire-tube boilers, the butt joint has done much, but such joints with the outside covering plate narrower than the inside are not ideal, and boilermakers should abandon them and use covering plates of equal widths.

In large mills the use of large boilers, say of 400 or 500 hp. instead of 150 to 200 hp., should be encouraged. The large boilers are just as safe, slightly more economical, take up less room, reduce the number of steam pipes, blowoff pipes, stop valves, blowoff valves, feed valves, water columns, steam gages, and reduce the amount of brickwork and pipe covering.

The use of stronger draft and more rapid combustion, with the object of reducing the number of boilers and firemen is to be encouraged, as the number of boilers in some mills is absurdly large. Coal can be properly burned at a rapid rate as at a slow rate. It is merely a question of adaptation of the method of firing, and firemen can be as well schooled to fire for rapid combustion as for slow.

Purchased Power

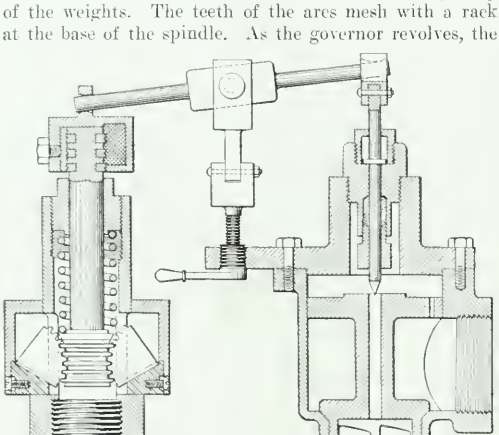
The outside central-station companies are making active efforts to sell electric power to textile mills as well as to mills and factories of other kinds. The price is given at so much per kilowatt-hour at the mill switchboard. They are especially anxious to do this because it keeps a plant the size of which is determined by the night-lighting requirements, from earning next to nothing during the daytime and they consequently are able to make low prices. Comparing the cost of producing power in mills with the cost of purchased power, the author has invariably found that it is advantageous for the mill to produce its own power. In textile mills it is more advantageous than in most other kinds, as the plants are usually of considerable size and adapted to the most economical production of power, due to their size and uniformity of load. This is particularly the case in mills where considerable steam is used, and, especially where exhaust steam can be used as for dyeing, to say nothing of slashing and heating. In such mills there is no chance for purchased power, and in mills where steam is used for power and heating only, every means for low cost of power which the public station can use is available to the mill with a probability of more care being taken in operation.

In factories where the power required is intermittent, and the shafting friction large, as in a boiler shop, purchased electric power is advisable, unless electricity is generated in some other part of the plant for other purposes. In either case electric individual driving is advisable.

The balance of the paper was devoted to an analysis of a circular giving the cost of power as produced by the Fitchburg Yarn Co. This was given as $16.68 per indicated horsepower per year. The analysis by Mr. Dean showed that a reduction to $15.10 would be possible.

Clark Centrifugal Governor

A compact form of governor for steam or hydraulic work has been designed by C. H. Clark, of New York City. Its action depends on the centrifugal force of a pair of sectors working against a spring. The construction is shown in the accompanying drawing. The edges of the sectors pivot in the lower corners of a casing surrounding the governor spindle. The proportions are such that the fulcrum is 2¼ times farther from the center line of the spindle than from the center of gravity of the weights. The teeth of the arcs mesh with a rack at the base of the spindle. As the governor revolves, the



Sectional View of Governor and Valve

weights tend to turn out and thus raise the governor spindle against the downward pressure of the spring. The upward push of the sectors increases with the speed of the governor in practically a straight line up to a displacement of nearly 80 deg., as does the pressure of the opposing spring. The construction limits the displacement to 45 deg. A balance between the two forces is thus readily effected and regulation within ½ of 1 per cent. from no load to full load is obtained.

The movement of the governor spindle controls a throttle valve by means of a pin designed to fit an opening through the valve body. The upper face of the valve has twice the area of the lower face. When the pin closes the opening, steam admitted through the small hole at the side, in the upper disk, builds up in pressure and forces the valve to its seat. As the pin recedes from the opening the steam above the disk escapes to the discharge side of the valve, and allows the upward pressure, which is now in excess, to open the valve. As a matter of fact, the valve floats on the line, following closely the movement of the pin. The two do not come in contact, but as a precautionary measure, the opening is made a shade larger than the diameter of the pin so that there can be no interference with the action of the governor.

For a quick-opening throttle or hand operation of large steam and water valves this same construction is recommended and has been applied in some cases by the inventor.

Standards for Ventilation Legislation

The report of the committee appointed by the American Society of Heating and Ventilating Engineers last year to formulate standards for ventilation legislation for motion-picture show places, and presented at the last annual meeting of the society in New York City, has just been approved by a mail ballot of the members. The report has been printed and is being distributed among the members.

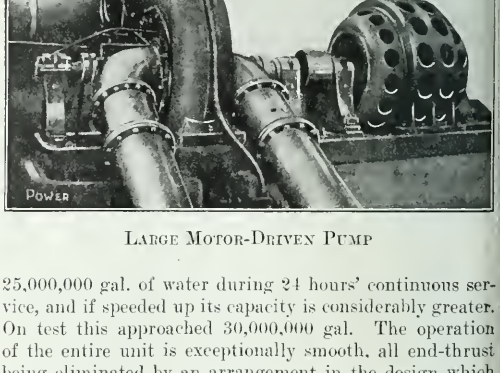
The society has on hand a generous supply of this report in printed form at its headquarters, 29 West Thirty-ninth St., New York City, and will be glad to furnish free copies to all engineers, boards of health, town councils, ventilation inspectors and others interested in the subject of proper ventilation of motion-picture show places.

Modern Pumping Units for Steel Mills

By C. A. Tupper

In the accompanying illustration is shown a very good example of the modern motor-driven centrifugal pumps, for handling large volumes of water daily, which are being installed by large industrial establishments throughout the country. This unit was built for a steel mill.

The pump, which has a snail-shell casing, is of the single-stage, double-suction type. Its working head is about 125 ft. Operating at normal speed, it will deliver



Large Motor-Driven Pump

25,000,000 gal. of water during 24 hours' continuous service, and if speeded up its capacity is considerably greater. On test this approached 30,000,000 gal. The operation of the entire unit is exceptionally smooth, all end-thrust being eliminated by an arrangement in the design which admits water from both sides, directly opposite the center of the revolving impeller, thus creating a balanced suction.

The efficiency of such a pump is dependent largely upon the velocity imparted by centrifugal force and the extent to which the kinetic energy can be converted into pressure as the water leaves the impeller, its force being the greatest at that instant. Accordingly, the most important improvements in the designing of large centrifugal pumps, both in the United States and abroad, have been in the shaping and arrangement of fixed dif-

fusion vanes to so guide the water that its velocity, as it leaves the impeller, is converted into the maximum of pressure with the least possible disturbance to its flow.

In the pump illustrated, the provision made for this is in line with the latest tendencies of American and European designs, although German engineers are working on a similar unit having movable diffusors.

It is interesting to note that, while the impeller shaft was made from an openhearth steel forging, it was decided, with the quiet operation, that the casing, impeller, etc., could be of a good grade of close-grain cast iron.

The motor driving this pump is of the wound-rotor induction type, which permits of variable speed. This is particularly important for starting. It operates on three-phase, 25-cycle current, at a potential of 440 volts, and normally develops 750 hp., with large overload capacity.

Marine Engineers' Dinner

Over 200 attended the eighteenth annual dinner of the Marine Engineers' Beneficial Association, No. 33, at the Broadway Central Hotel, New York City, April 23, 1913. National President William F. Yates presided as toastmaster and after a few words of welcome introduced Thomas McGill, secretary to the new dock commissioner, the Hon. R. C. H. Smith. In behalf of the commissioner, Mr. McGill told something of the aims and plans of the Commission, particularly with respect to the improvements in the dockage facilities for the Trans-Atlantic liners.

The remainder of the evening's entertainment was in the form of song and story, a very interesting program having been arranged by Frank Martin. Among those who entertained were the Dixie female quartet, Herbert Self, Jack Armour, Billy Murray, Jim Devins, Joe McKenna and Miguel O'Connell.

A 19x21 Lentz engine is said to have made a record of 16 lb. of steam per indicated horsepower-hour upon the testing floor of the Erie City Iron Works, its builders. The initial pressure was 125-lb. gage, superheat 200 degrees and the exhaust into the atmosphere.

To Reorganize Northern Colorado Power Co.

The plan of reorganization of the Northern Colorado Power Co., which was offered by Vice-President Chambers of the Electric Properties of New York, to the executive committee of Denver stockholders' association and which calls for a reduction of bonded indebtedness and reissuance of new stock for that now outstanding, is reported to have been rejected by the Denver committee.

It was stated, however, that Mr. Chambers had two other plans of reorganization to offer at the stockholders' annual meeting on April 24. Under the plan that was submitted the bonds would be reduced from $2,500,000 to $2,000,000, and to compensate the bondholders for this reduction they would receive new common stock to the amount of 20 per cent. of their holdings. The new stock issue will be the same as at present—$1,000,000 6 per cent. preferred and $2,000,000 common.

Central States N. A. S. E. Conventions

The Central States Exhibitors Association will have charge of the exhibit at one more state N. A. S. E. convention this year, Ohio being the additional one.

Following are the convention cities, dates, official headquarters, hotels and hotel rates:

Kentucky, Hopkinsville, May, 7, 8, 9, Hotel Latham, American plan $2 to $3 per day.

Missouri, Springfield, May, 14, 15, 16, Metropolitan Hotel, American plan, $1 up per day.

Iowa, Burlington, May 21, 22, 23, Hotel Burlington, European plan, $1.50 to $3 per day.

Illinois, Rockford, May, 28, 29, 30, The Nelson Hotel, American plan, $2.50 up per day.

Indiana, Terre Haute, June, 4, 5, 6, Terre Haute House, American plan, $3 up per day.

Ohio, Toledo, June, 11, 12, 13, Boody House, European plan, $1.50 up per day.

Michigan, Grand Rapids, June, 18, 19, 20, Hotel Pantlind, European plan, $1.50 up per day.

Wisconsin, Milwaukee, July, 9, 10, 11, Republican House, American plan, $2.50 up and European plan, $1.50 up per day.

Minnesota, Duluth, July, 16, 17, 18, Hotel Spaulding, European plan, $1 up per day.

Banquet of the Marine Engineers' Beneficial Association No. 33, in New York, Apr. 23, 1913

Difficulties of Running a Power Plant

I. E. Moultrop, the mechanical engineer of the Edison electrical plant, gave an informal talk before the Massachusetts Institute of Technology student branch of the American Society of Mechanical Engineers. His subject was "The Difficulties of Running a Power Plant," which he selected for the especial benefit of the seniors, who are now making a power-plant design.

Some of the points taken up were the difficulties of boiler setting, uses of the economizer, condensers, mechanical stokers, automatic conveyors for coal and ashes, and steam piping. Mr. Moultrop said that economizers should not be used without a fan. They are also of no use in small plants where the load is variable, but are especially well adapted to large plants where the load is steady. He also took up the advantages and disadvantages of mechanical stokers. With good apparatus it is possible for one man to tend from four to eight boilers. The saving made in this way is enough to offset the overhead expense.

The talk was very informal, being more like a conference than a lecture. Many questions were asked, and everything was explained with much clearness. The speaker was a man of great personality, the ideal engineer, and the members of the society all felt that they had benefited greatly from the talk.—"Tech."

Experience for Seattle Students

An example of the very practical nature of the power-plant engineering courses of the Seattle Engineering School is given by the following incident:

The Tacoma-Roche Harbor Lime Co.'s vessel, the "Archer," had been tied up for a number of days because its 300-hp. gas engine, operating with a producer-gas plant which, at the time it was installed a few years ago was claimed to be the largest producer gas plant in the world and is now the largest on the Pacific Coast, was badly out of order, owing to the difficulty in securing competent men to operate it and keep it in working condition.

Responding to the request of the president of the lime company, the school sent its gas engineer and a crew of advanced students in gas engineering to the "Archer." They overhauled the producer plant and engine, found the troubles and corrected them, and soon put the vessel into commission.

Incidentally, one of the students who assisted in the work was employed by the lime company to operate the "Archer's" gas producer, and he is now regularly with the ship. This also shows the great need of competent, trained gas engineers on Puget Sound.

Report Regarding Keokuk Plant False

A New York newspaper recently announced that work had stopped on the Keokuk hydroelectric plant, though the project was but half completed. The report states that only 150,000 hp. will be generated instead of the 300,000 hp. as planned, intimating that the whole development was to be carried out immediately but that lack of financial support has necessitated cutting the installation in half.

Those who have followed the project know that the intention from the start has been to develop only 120,000 hp. at present, and that expansion was not to come for some years. Moreover, all of the concrete has been in for some time, the superstructure is completed, the turbines and electrical machinery are practically all in place, and the transmission line to St. Louis is finished.

The report, therefore, is manifestly erroneous. Moreover, the New York office of Stone & Webster denies that there has been any cessation of work or embarrassment in funds.

SOCIETY NOTES

The New England Society of Superintending Engineers held its regular monthly meeting and dinner on the evening of Apr. 26 at the American House, Boston. Several prominent engineers were admitted to membership. A very interesting talk was given by F. L. Fairbanks on the construction of boilers, after which there was a general discussion of the subject.

The American Order of Steam Engineers will hold its twenty-seventh annual convention in the Parkway Building, Broad St., Philadelphia, on June 2 to 7. The Windsor Hotel will be the association headquarters. The local committee and that of the American Supply Men's Association have their arrangements almost completed, and declare that this convention will prove a highly affair.

At the semi-monthly meeting of the Detroit Engineering Society on the evening of May 2, Clarence W. Hubbell, chief engineer of the Bureau of Public Works, Manila, P. I., delivered an interesting informal talk on "Public Works in the Philippine Islands." Mr. Hubbell is a member and former secretary of the society and has been identified with the public works of the Philippine Islands for several years.

OBITUARY

E. M. ADAMS

E. M. Adams, president of the Ohio Society of Mechanical, Electrical and Steam Engineers, and for a number of years chief engineer of the Quaker Oats plant at Akron, Ohio, died suddenly of diabetes on Apr. 17.

JAMES TANGYE

James Tangye, one of the Tangye brothers so well known in English mechanical circles, died at his home in Cornwall, on Apr. 4, aged 88 years. While each of the brothers, of whom George Tangye is the survivor, did his share to build up the well known firm of Tangyes, Ltd., it is generally accepted that James' work and influence were foremost up to the time of his retirement from active work in 1872, while still a comparatively young man.

Possibly James Tangye's application of the principles of hydraulics, his earliest introduction to which was in connection with Brunel's testing machine, was among his most important labors, at all events as regards the fortunes of his firm.

His introduction of the portable hydraulic jack caused an immense stir in engineering circles at the time and brought about a revolution in manufacturing methods. As pointed out by "The Engineer," it is a curious fact that this appliance as it came from his pencil has remained very nearly unaltered until the present day. James Tangye also applied the principle of his jack to a number of other purposes, and designed a series of handy tools for punching, shearing and otherwise manipulating iron by hand, as well as special presses for a variety of uses.

James, at the suggestion of his brother, also got out the drawings for a series of steam engines of different powers which could be made to standard. This was an entirely novel departure, all engines having previously been made one by one and without any reference to interchangeablity of parts. Of these drawings it is stated that, like all that ever proceeded from his hands, the design was produced once for all, and needed no retouching or modification as long as the conditions for which it was intended remained unaltered. In these engines the overhanging cylinder, the crank plate and the form of connecting rod were all innovations. The engine was an advance on anything of the kind previously introduced. The high-speed governor was also more delicate and efficient than any of its predecessors. Having designed the series of engines, James set himself to evolve improved methods of manufacture, and the introduction of jigs is attributed to him.

PERSONALS

Thomas G. Oakes, recently connected with the New York office of the Nelson Valve Co., is now associated with the Shipley Construction & Supply Co., New York City.

A. Richard Foley, of the Home Rubber Co., sailed for England on the "Mauritania" an Apr. 23. Mr. Foley will assume the management of that company's London office.

J. H. Stretton recently resigned as chief engineer of the Baltimore Hotel, Los Angeles, Calif., to accept the position as chief engineer of the W. H. Constable Co.'s warehouse and cold storage plant at El Paso, Texas.

E. F. Putnam, formerly sales engineer with the Edison lamp department of the General Electric Co., has been appointed commercial manager of the United Electric Light & Water Co., Greenwich, Conn. Mr. Putnam has also been connected with the Public Service Electric Co., at Camden and Newark, N. J.

POWER

Vol. 37 MAY 13, 1913 No. 19

The Business End of the Power Plant

LOWER cost for power means increased dividends. However, as the power plant is not classed as a productive division, the possibilities for increased economy there are often overlooked; a productive department produces the marketable goods and therefore seems worthy of more attention. But do the figures of the last audit substantiate that belief? Certainly not. Although the power cost forms a small per cent. of the total costs in nearly all industries, it runs into thousands of dollars, and losses there reduce the dividends the same as losses in other departments. And, *a thousand dollars saved or spent in the power plant is real money.*

This foreword is written chiefly for the power-plant owner.

The engineer should pass along his copy to the owner, superintendent or manager, as there is much of interest in it to them.

It is the engineer's business to furnish maximum power at a minimum cost, but, to do this, he must be supported by the management. The productive and selling departments demand great attention, but if a part of what is gained there is lost in the plant, the whole organization needlessly suffers. Therefore help the engineer to improve the service and he will furnish it at a figure that only the plant itself may excel.

European manufacturers, particularly the Germans, whose industrial and commercial thoroughness enables them to drive out all competitors supplying South American markets, and nearly all in the Oriental markets, devote much attention to their engineers and power plants. They help support engineering schools and buy testing instruments and apparatus with which the engineer may detect, remedy and prevent thermal and mechanical losses. It's not charity; it's a very profitable investment which the manufacturer is anxious to make. A few of the advantages gained are: High-class service at low cost, freedom from labor troubles, astonishingly few accidents and a low maintenance cost.

The engineer desires that the firm have something more than continuous service. He knows that uninterrupted power may be supplied to the producing machinery and yet be poor because of its high cost. Therefore consider his advice and recommendations. Furnish him with record and report forms that he may record the performance of the plant. There is no better way of improving a plant than by analyzing its operation by reference to records. They reveal weaknesses that are difficult for the engineer to discover otherwise.

Competition is *fierce* in the market receiving the manufactured goods, but it does not end there. The company's power plant also has a competitor that sells power for *profit*. It is watching for those weak spots that the engineer could have prevented if the management had given him support, and when the time is ripe will advance with smooth speech and convincing-looking figures to show the fallacy of generating power instead of buying it. If fair and thorough investigation shows that it is cheaper to buy it, do so. But help the engineer, and call in a consulting engineer, if he recommends it, to aid him in generating power cheaper than it can be bought. The profits will then remain in the company's vault instead of being charged to the expense sheet.

McCalls Ferry Hydro-Electric Plant

By Charles H. Bromley

SYNOPSIS—The McCalls Ferry hydro-electric plant on the Susquehanna River, near Lancaster, Penn., is within a radius of 70 miles of where over 750,000 hp. is developed by steam. The present rated capacity is 84,500 hp. and another 17,500-hp. unit is being installed. Provision is made for three more 17,500-hp. units, making an ultimate rated capacity of 135,000 hp. The tailrace of this plant is a natural one. The current of the river is such as to carry away all ice. The entire daily load, averaging 30,000 kw. with a maximum peak of 61,000 kw., is now going to Baltimore. The generators deliver three-phase, 25-cycle current at 11,000 volts and it is transmitted at 70,000 volts.

Historical

The location of the McCalls Ferry plant is ideal. Within an economical transmission radius of 70 miles are several of the largest cities of Pennsylvania, Maryland and Delaware. The map, Fig. 1, shows cities within this radius.

The site for the plant had been under consideration for many years, the investigations being carried on by George S. Morrison, deceased. The river showed a record flood of 225 volumes of low-water discharge. A series of rapids above the present location make available a head of 63 ft. This site was determined by Mr. Morrison.

About 1905 the McCalls Ferry Power Co. was incorporated with a capital of $10,000,000. This company designed the present dam and power house and carried on the construction work until 1907, when the financial panic of that year caused the company to fail. It will be understood that this failure was purely a financial one. The engineering scheme was successfully laid out as is evidenced by the fact that the present owners, the Pennsylvania Water & Power Co., which took over the plant about two years after the first company failed has practically carried out what was initially planned.

The engineering organization of the McCalls Ferry Power Co. consisted of Carey T. Hutchinson, 60 Wall St., New York City, as chief engineer. The hydraulic plant was designed and partially executed by Hugh L. Cooper, 60 Wall St., New York City. Beverly R. Value was engineer in charge of construction.

Construction

The plant and dam were built by day's labor, as exhaustive study of conditions proved this course the best. The dam is approximately 2370 ft. long, 53 ft. high, with a base width of 65 ft. To allow for expansion and

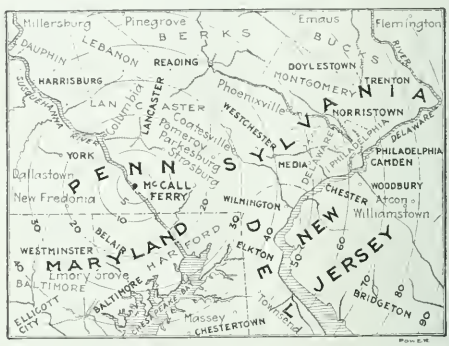


Fig. 1. Map Showing Cities within Economical Transmission Distance

contraction, and thus avoid cracking and deformation, layers of compressible material were inserted at intervals of 40 ft.

The Susquehanna is a widely and suddenly fluctuating river, and special provisions were necessary in constructing the dam. The dam was thus built in alternate sections, each 40 ft. long, average height 53 ft. with a 40-ft. space between each section to provide for a flow of 50,000 cu.ft. per sec. These spaces were filled in later to form a solid dam. To stop the openings between sections, hol-

Fig. 2. Panorama of Dam and Power House, Showing Deflecting

low stop logs, consisting of steel skeleton frames were provided for each opening. To divert the flow of water and allow of filling in the spaces between sections these stop logs were lowered into the spaces and heavy canvas curtains made to cover the upstream side of the framework. Lengths of large hose were placed at the sides and bottom and then inflated with air; the space then became dry. It is estimated that over $400,000 was saved by the use of these stop logs instead of building coffer-dams for the purpose.

After the necessary coffer-dams were built, first one from the Lancaster or east shore and then one from the York or west shore, a construction bridge was built on the down-stream side of the dam. It was thought that the flood waters of the river would undoubtedly carry away the usual temporary trestle work used for construction purposes, hence the use of the construction bridge. The Lancaster end of the bridge was 1100 ft. long, arch form, with 40-ft. spans, and had a roadway 50 ft. wide. The York end of the bridge was of the same design but 900 ft. in length.

Huge traveling-boom cranes ran on tracks on this construction bridge to deposit steel and concrete. Interchangeable steel forms were used in the construction of the dam.

An idea of the rapidity with which the work was done and the volume of material handled is gained from the fact that a concrete-mixing plant was built with a mixing capacity of 2000 cu.yd. every 10 hr. and a storage capacity of 14,000 cu.yd. for concrete material. This plant was later destroyed by fire.

The flow of the river at the head of the dam is westward, while the power house is on the east shore. This flow carries ice away from the power house. However, a wing dam, right background, Fig. 2, having three submerged arches, through which water enters the forebay was built at right angles to the main dam and, with the aid of floating booms, diverts ice into the main stream where it is carried away. The wing dam terminates at a meter house containing a meter for recording the height of water in the forebay. Two ice chutes in the power house and three on the shore end permit of the disposal of ice. A deflecting wall, separating the main stream from the tailrace, serves as a walk to Piney Island (right foreground, Fig. 2), where are located the first transmission-line towers and the arc-extinguisher equipment.

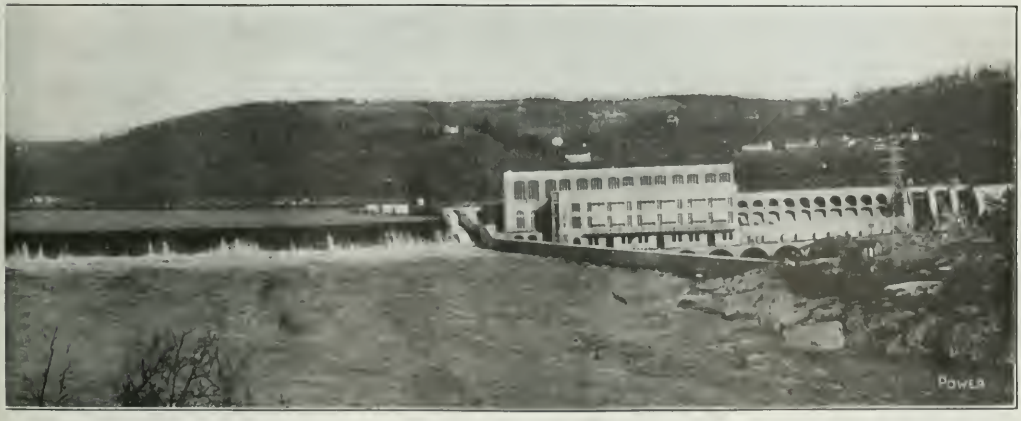
The tailrace, Fig. 3, is a natural one throughout its entire length of two-thirds of a mile. It is formed by the east shore of the river and Piney Island, also a few other smaller islands. The spaces between the islands were closed by cribs and rock fills. About 150,000 cu.yd. of rock were removed at the lower end of the tailrace to obtain a head of 53 ft.

FIG. 3. NATURAL TAILRACE

The fishway, extreme right, Fig. 2, is in two sections, each 8 ft. 10 in. wide, 254 ft. long, with a slope of 1 to 4. Each section contains wooden barriers every 6 ft. to break the velocity of the flow and to form eddies where the fish may rest.

THE POWER HOUSE

The generator house, i.e., that part of it below the rails of the 100-ton crane (see Fig. 4) and also the gate house are of solid concrete. The walls of the transformer



WALL, TAILRACE ARCHES, FISHWAY AND TOP OF CONSTRUCTION BRIDGE

house are of reinforced concrete. The power house was originally designed to provide space for ten 13,500-hp. turbines. The concrete superstructure is already in place, so that to install more units all that is necessary is to run in the parts on a spur track, erect the unit, and add the necessary length to the power house.

As shown in the transverse section, Fig. 5, the main generating room is in the center with the rheostat gallery and gate house on the right and the transformer house on the left. A machine shop is located at the rear of the transformer house.

Turbines

Although space for 13,500-hp. turbines was provided for in the design of the plant, the present owners found that units of 17,500 hp. capacity could be installed without altering the pits. This was done with unit No. 6 and the seventh unit, which is also of 17,500 hp. is now being installed; each of the first five units are of 13,500 hp. capacity. The first four units were originally connected to 7000-kv.-a., three-phase, 25-cycle, 11,000-volt generators, but the present owners rewound units Nos. 1 and 2, increasing their capacity to 10,000 kv.-a. each.

As shown in Fig. 5, the turbines are provided with double draft tubes. This is necessary because of the varying height of the tail water. The penstocks, wheel chambers and draft tubes are of concrete. The recent high water, reaching a height of 13 ft., going over the dam on Mar. 29, reduced the head by 10 ft., but did not cause any trouble at the plant.

The turbines each have two wheels on a single shaft, the load of 410,000 lb. being carried at some of the turbines by roller bearings, and at others by thrust bearings known as the Kingsbury bearings. This bearing is described and illustrated on page667of this issue.

The turbine rotors are so heavy that it is not desired to lift them with the 100-ton crane provided in the generator room. For this purpose a high-pressure, double-acting pump mounted on a truck is fitted so that the suction end may be quickly connected to the oil reservoir of the thrust bearing; the discharge is connected to the oil pipe discharging directly into the bearing, which serves as a hydraulic jack. By operating the pump with compressed air the rotor may be lifted and when raised may be held by a rachet arrangement at the side of the casing. By mounting the pump on a truck it may be easily moved to any turbine.

Control of Main and Exciter Turbines

There are two 250-volt, 400-kw., compound-wound, interpole-exciter units, running at 240 r.p.m., and one 250-volt, 500-kw., compound-wound, interpole unit, running at 750 r.p.m. The first two are driven by water turbines of 1000 hp. each at 240 r.p.m. with 53-ft. head. The third unit is driven by a synchronous motor of 750 hp., 25 cycles, three-phase and 10,500 volts; Fig. 6 shows the exciter units.

As there are six main units and two turbine-driven exciters there are thus eight governors which are of the gear-driven, double-floating-lever type. The actuating power system for the governors is most complete, there being five motor-driven, six-stage centrifugal pumps and one turbine-driven triplex pump. The pump room is located at the left of and below the generators. The floor has a transverse slope of ¼ in. to the foot toward a 10-in. gutter to provide for drainage. There are two 5-in. single-stage centrifugal-drainage pumps driven by direct-current vertical motors of 50 hp., 220 volts, 750 r.p.m. The actuating power system for the governors is laid out as follows:

The five motor-driven centrifugal pumps and the one turbine-driven triplex pump take water through a 14-in. line from the forebay and deliver at 300-lb. pressure into a 10-in., 8-in. and 5-in. pipe line leading to three steel accumulator tanks on the turbine floor. An air compressor driven by a 7.5-hp., 220-volt, direct-current motor running at 1100 r.p.m., furnishes air to these accumulator tanks to create a cushion effect in the system. The

Fig. 4. Interior of Generator Room

compressor also furnishes air to brakes on the turbine shafts. From these tanks the high-pressure water is led to the cylinders operating the wicket gates controlling the flow of water to the turbines, the admission and release of water from these operating cylinders being controlled by the turbine governors, the speed of which varies as the speed of the turbines. The operating cylinders are much the same as a steam-engine cylinder and are pro

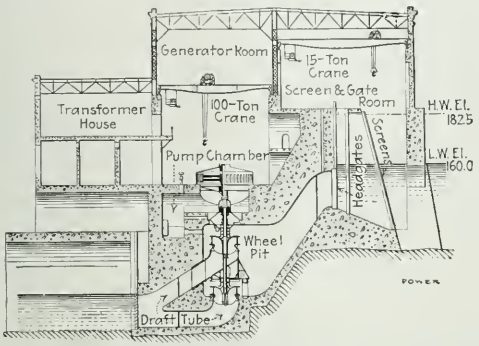


Fig. 5. Transverse Section of Power House

vided with an index pointer moving over the face of a graduated gage which indicates the percentage of gate opening. As the water used in this high-pressure system becomes quite warm it is cooled after being discharged from the operating cylinders into the "sump" tanks; the cooling water passing through brass-welded coils submerged in the "sump" tanks, of which there are three.

To avoid recourse to hand control of the operating cylinders, two of the five motors driving the 5-in., six-stage centrifugal pumps in this system are of the induction type, 300 hp., three-phase, 25 cycles, 665 amp. per terminal, running at 1440 r.p.m. The other three are direct-current motors, two being of 150 hp., 220 volts, running at 1530 r.p.m., and the other is 100 hp., 220 volts, 375 amp., running at 1700 r.p.m., and is direct connected to a six-stage centrifugal pump capable of discharging 150 gal. per min. at a 300-lb. head.

As mentioned before, there is a triplex pump, turbine driven, also connected to this system. It is thus realized that if the alternating-current supply fails, the direct-current motors may be started, and *vice versa*. It is possible also to maintain the pressure with the turbine-driven triplex pump. Three of the high-pressure service pumps are connected for pumping water out of the pump room in case it should be flooded, and for delivering water for house purposes to the dwellings on the hill, right, Fig. 2, occupied by the working force at the plant.

Lubrication System

In this system the oil flows from two storage tanks, each of 3000 gal. capacity, located in the gate house and connected to a header located on the wall of the passageway where the wheel-gate-operating pumps are situated. This header is connected to the storage tanks by duplicate pipe lines, so that in case of a breakdown in one storage tank, the other may be placed in commission, and in this way the system is insured against a shutdown.

From the above header, each generating unit is fed by separate pipe lines. The dirty or used oil is collected in a pipe header and flows by gravity to the filter. This filter has a capacity of 125 gal. per min., is equipped with cooling coils, and also has a storage capacity of 4700 gal., which allows the oil to be run to the filter in case of accident to a storage tank.

In this filter the oil is cleansed and cooled and from here is pumped to the storage tanks by motor-driven centrifugal pumps. By means of a bypass in the piping system, oil from these pumps may be placed directly into the header which supplies oil to each generating unit.

Sight-feed indicators, with electrical attachment, are placed in each feed line, so that in case of an accident to the feed line, the operator is apprised by an annunciator which is connected to these sight flows. Thermometers are placed in the storage tank and also at each outlet of each generating unit.

Electrical Equipment

The exciters deliver current to duplicate sets of busbars, each set taking care of one-half the plant. The voltage is regulated automatically by a regulator mounted on the switchboard. This regulator can handle one, two or all three exciters. Provision is also made for a duplicate regulating system for operating the plant as two separate divisions of units.

Transformers

The transformer house provides space for 10 three-phase transformers for stepping up the voltage from 11,000 to 70,000 volts. The transformers are rated for a

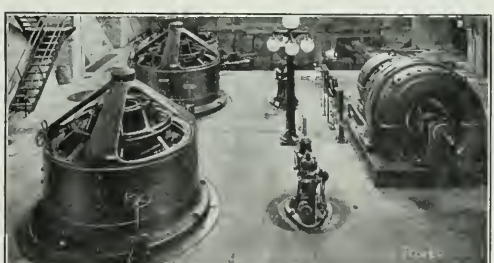


Fig. 6. Showing the Three Exciter Units

maximum of 300,000 volts. Seven transformers are now installed, five being of 10,000 kv.-a. capacity, two of 7500 kv.-a. capacity. The first 10,000-kv.-a. transformer was the largest ever built at the time of its installation. They are elliptical, 15 ft. 11 in. long, 8 ft. 8 in. wide and 16 ft. high.

The windings are delta connected on the low-tension side and star connected on the high-tension side. The neutral is grounded through resistance "stacks" connected in series. All transformers are of the shell type mounted on wheels so that they may be run out under the 100-ton Morgan crane in the generator room.

The smaller transformers are oil cooled. The larger ones are oil insulated and internally water cooled. The water gravitates to the transformers, passing through them to coils in concrete tanks under the arches of the transformer house. The cooling water is taken from the forebay. The covers are equipped with vents, consisting of lead gaskets which break when the pressure gets too

high in the tank. The high-tension terminals are brought out of the tanks through oil-cooled bushings.

The substation at Baltimore has five 10,000-kw. transformers to step down the line voltage of 60,000 to 13,200. These transformers are oil insulated and externally water cooled. The cooling system consists of two motor-driven centrifugal pumps, each of 350 gal. per min. capacity. One of these pumps takes water from an artesian well and discharges it to a 10,000-gal. tower elevated 65 ft. above the transformer bases. After gravitating through the transformers, to a cistern, the other pump lifts the water to the roof where it is prepared for rapid cooling by passing through spraying nozzles. It then runs down to mix with the colder well water, after which the cycle is repeated.

Besides the main transformers in the plant there are two station-service transformers, circuits 11,000 volts to 230 volts. A 300-kw. testing transformer of 300,000 volts maximum voltage, excited by a step-down transformer of 200 kw. capacity, 11,000, 2200 volts is also provided. The testing load is obtained by a water rheostat designed for 15,000-kw. continuous load. Another transformer, 150 kv.-a. capacity, 11,000 to 250 volts, is used for lighting Holtwood (name of settlement at plant) and for the construction plant.

Busses, Switchboards and Storage Batteries

The station is provided for six outgoing, 70,000-volt, 300-amp. lines. Provision for six outgoing, 11,000-volt, 300-amp. local feeders also obtains.

The busses are of hollow-copper tubing. Each generator delivers current either to the low-tension bus or step-up transformers or to both at the same time. Thus there are ten groups of oil switches, each group having a generator switch, a transformer switch and a tie switch. Disconnecting switches are installed on each side of every circuit-breaker so that they may be cleaned and inspected with safety.

The feature of the busbar system is that the high-tension busses are in duplicate, sectionalized at the center and tied together at the ends by oil circuit-breakers. This makes a complete ring bus capable of being operated in one, two, three or four sections. Any of the six lines and any of the ten transformers may be connected to any of the ten high-tension busbars by selective oil switches.

The entire plant is controlled from a benchboard, Fig. 7, on a gallery overlooking the generating room. The generator rheostats on the gallery opposite their respective generators are motor operated, as are the field circuit-breakers. The exciter board is on the rheostat gallery and contains panels for each of the three exciters. Five other panels provide for service to motors for cranes, pumps, headgate hoists, etc. Each individual circuit is provided with automatic circuit-breakers, voltmeters and ammeters. All switchboards are of natural-oiled slate.

The main control board contains ten sets of panels for generators and transformers. The benchboard contains one control switch for each generator oil switch, transformer oil switch, low- and high-tension side, generator-field rheostat and governor control. The usual red and green lamps are provided in each control-switch circuit. Both the high- and low-tension bus systems are reproduced in mimic on the benchboard. The control switches for the signal system in the generator and pump rooms are also mounted on the vertical panels. An intercommunicating telephone system is also installed in the plant.

On the rear panels of the benchboard facing the switch-room are mounted the generator intergrating watt-hour

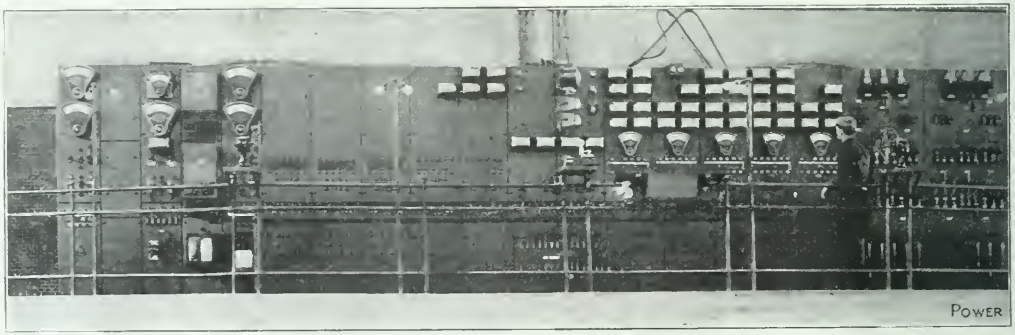


Fig. 7. Benchboard, Showing Panels in Use and for Future Installations

meters; the definite time-limit relays protecting the generators; the inverse time-limit relays protecting transformers, outgoing lines and feeders, and instantaneous relays protecting the station-service circuits and testing equipment circuits.

Storage Batteries

In the transformer house is a small, glass-jar cell, storage battery used in emergencies to supplement the 250-volt, direct-current supply to circuit-breakers, oil switches, etc. A wooden-tank cell, battery of 142 cells, with 37 end cells, is installed in a compartment in the gate house. This battery is expected to carry the entire excitation load for one hour.

Transmission Lines

The right-of-way to Baltimore is 100 ft. wide and 40 miles long. The lines are in duplicate, each set having three cables, the current being three-phase. The cables, 300,000 circ.mils in size, are of aluminum and suspended from the steel towers by strain insulators where long spans or angles occur and by suspension insulators in straight-away work. There are 415 towers, ranging in height from 63 to 135 ft. The longest span in the line and one of the longest in the world is 1800 ft., between

PRINCIPAL EQUIPMENT McCALLS FERRY POWER PLANT

Equipment	Type	Use	Kw.	Volts	Amp.	Cycles	Phase	R.p.m.	Head	Hp.	Manufacturer
5 Turbines	Vertical	Generator drive		.		.		94	53	13,500	I. P. Morris Co.
2 Turbines	Vertical	Generator drive		.		.	.	116	53	17,500	I. P. Morris Co.
2 Turbines	Vertical	Exciter drive		.		.		240	53	1,000	I. P. Morris Co.
4 Generators	Alternating, vertical	Light and power	10,000	11,000	525	25	three	94	..	..	General Electric Co.
1 Generator	Alternating, vertical	Light and power	7,500	11,000	392	25	three	94	..	.	General Electric Co.
2 Generators	Alternating, vertical	Light and power	12,000	11,000	650	25	three	116	..	.	Westinghouse Electric & Mfg. Co.
2 Generators	D. C. Vertical	Exciter service	400	250	1600		..	250	..	...	Westinghouse Electric & Mfg. Co.
1 Generator	Motor generator set Synchronous	Exciter service	500	250	2000		.	750	..	...	General Electric Co.
1 Motor	Motor generator set	Exciter service		10,500	31 8	25	three	750	..	750	General Electric Co.
1 Switchboard	Benchboard	Remote control	.	.	.	.	.	...	..	...	General Electric Co.
3 Transformers	Water cooled	Voltage step up	10,000	11,000 70,000		25	three	..	..	...	General Electric Co.
2 Transformers	Water cooled	Voltage step up	7,500	11,000 70,000		25	three	..	..	...	General Electric Co.
2 Transformers	Water cooled	Voltage step up	10,000	11,000 70,000		25	three	..	..	...	Westinghouse Electric & Mfg. Co.
1 Transformer	Oil cooled	Voltage step down		11,000 2,200			.	.	..	..	General Electric Co.
1 Transformer	Oil cooled	Testing		Maximum 300,000			.	.	..	...	General Electric Co.
1 Transformer	Oil cooled	Voltage step down	200	11,000 550			.	.	..	...	General Electric Co.
1 Transformer	Oil cooled	Station service	..	11,000 200			.	.	..	...	General Electric Co.
1 Storage battery	Glass jar	Station service							.	...	Gould Storage Battery Co.
1 Storage battery	"Chloride accumulator"	Emergency							.	...	Electric Storage Battery Co.
2 Motors	Direct current	Accumulator pump drive		220	375			1700	.	100	Westinghouse Electric & Mfg. Co.
3 Motors	Induction	Accumulator pump drive			665	25	three	1440		300	Westinghouse Electric & Mfg. Co.
2 Motors	Direct current	Accumulator pump drive		230	540	..	.	1530		150	General Electric Co.
2 Motors	Direct current	Drainage pump drive	.	220	190		.	750	.	50	Westinghouse Electric & Mfg. Co.
2 Motors	Direct current	Oiling system		230	37 7	.		1700		10	Westinghouse Electric & Mfg. Co.
1 Motor	Direct current	Air compressor drive	...	220	28			1100		7.5	National Brake & Electric Co.
				Static		Size			Pressure		
2 Pumps	Centrifugal	Oiling system		single		2½ in.					Henry R. Worthington Co.
2 Pumps	Centrifugal	Drainage system		single		4 in.					I. P. Morris Co.
5 Pumps	Centrifugal	Accumulator pressure		6		5 in.			350 lb.		I. P. Morris Co.
1 Pump	Triplex	Accumulator pressure		..		3 in.			350 lb.		Deane Steam Pump Co.
1 Air compressor	Motor driven	Plant supply		..		...			350 lb.		National Brake & Electric Co.
Lubrication system											Peterson Engineering Co.
2 Cranes											Morgan Engineering Co.

Piney Island and the York shore of the river. Horn gap lightning arresters are provided where the lines leave the station. On Piney Island there is an elaborate arc-extinguishing equipment to minimize the troubles due to electrical storms. This equipment is shown in Fig. 8. The towers carry a private telephone line connecting the power plant, patrol stations, substations, and the steam plants of the Baltimore Gas & Electric Co., and United Railways Co. of Baltimore which act as standby stations for the McCalls Ferry plant.

The transmission line to Lancaster, Penn., is nearly completed and it is expected that at least 10,000 kw. will be sent over these lines this coming June.

The present plant with its transmission line, substations, etc., cost nearly $16,000,000.

The engineering department of the Pennsylvania Water & Power Co., with offices at Baltimore, Md., is composed of J. A. Walls, chief engineer; F. A. Allner, general superintendent; A. Benson, assistant chief engineer; P. L. Smith, superintendent of operation; A. Bang, chief testing engineer; W. P. Baker, superintendent of installation, and T. C. Stabley, chief operator.

FIG. 8. ARC-EXTINGUISHER EQUIPMENT ON PINEY ISLAND

Furnace for Horizontal Tubular Boiler

By R. Cederblom

SYNOPSIS—The author hopes to obtain complete combustion by passing the gases through a perforated arch like that in the Broman furnace (see Power, *Feb. 4, page 171), *and then get best results by the scrubbing action of the gases on the heating surface. The scrubbing effect is produced and made intense by passing the gases, by induced draft, through narrow passages between the shell and walls or bridges.*

Every experiment along the line of increased evaporation in boilers shows that it is a matter of getting the hot gases in close contact with the metal and making them sweep over the surface at a high velocity to give a scrubbing action. The boiler must be built to give rapid and positive circulation to the water so as to take up the heat as fast as it is applied.

With return-tubular boilers as ordinarily built and with a common setting, the results would probably not be good, should we try to double the capacity by doubling the grate area. The circulation in this type of boiler is not as good as in a water-tube boiler, also the 4-in. fire tubes—the usual size—are not as effective as might be desired, prob-

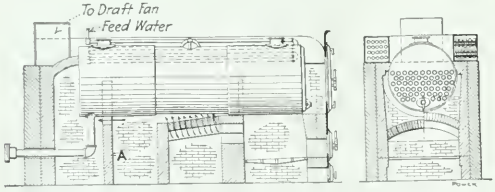


Fig. 1. Showing Large Combustion Chamber

ably because of such large diameter that part of the gases pass through without making good contact with the metal, thus increasing the stack temperature when trying to force this type of boiler. With some modification, however, in the way of both boiler and furnace construction, as good results could be had from a return-tubular boiler as from any other kind, and if so this type of boiler would have many advantages over the water-tube construction.

The ordinary conditions are 10 or 12 sq.ft. of heating surface per boiler horsepower, which means about 3300 B.t.u. absorbed per hour per square foot of surface, and with the usual rating of one to forty and an evaporation, of, say, about 7 lb. of water per pound of coal, we have 20 lb. of coal burnt per sq.ft. of grate. This is far from the 48,000 B.t.u., or 80 or 100 lb. of coal burned per square foot of grate which has been accomplished in recent experiments and with as good results in regard to efficiency as under the ordinary slow rate of combustion and evaporation.

In a locomotive boiler the firebox generally evaporates from 30 to 40 lb. of water per hour per square foot of surface, and there is no reason why the lower sheets of a return-tubular boiler should not be as effective and doubtless are, if the heat is applied in the right way. In the ordinary setting, however, this is not done, as a large per cent. of the gases never gets in contact with the shell. Where smoke ordinances are in force, the biggest part of this surface is often made ineffective by brick arches, piers, etc., throwing the flame away from the shell instead of toward it, the flame often not coming in contact with the boiler at all until it strikes the rear head and enters the tubes.

Theoretically this should not make any difference, as there is ample surface in the tubes to take up all the heat produced by combustion, but for some reason this does not work out practically. Probably this is because the circulation around the tubes is not what it could be with proper arrangements. Also it may be due to the fire side of the tubes being more or less covered with soot. Soot seems to form more readily on the thin metal of the tubes than on the boiler plate, probably because the temperature of the tube surface is nearer to that of the water than is that of the comparatively thick plate.

What arrangement should we have for a practical ap-

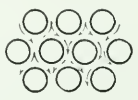


Fig. 2.

Fig. 3.

Action of Water on Staggered and Straight Rows of Tubes

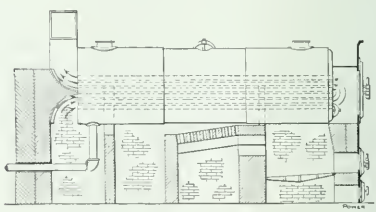


Fig. 4. Two-Pass Boiler

plication of these methods to a return-tubular boiler 60 in. by 18 ft., ordinarily rated at 100 hp. but intended for an output of 200 hp. with 50 per cent. overload if necessary?

The principal requirements are: High rate of combustion, high gas speed, close contact between gas and heating surface and as long passage as possible from the grates to the uptake.

High rate of combustion may be obtained from either forced or induced draft, but in this induced draft will be used to get high gas speed. To create this draft we must sacrifice a certain per cent. of the boiler output, but, on the other hand, the higher effieciency invariably gained by such means will often more than offset this loss.

At a rating of 200 hp., which means 6000 lb. of water evaporated per hour, and with an evaporation of 8 lb. of water per pound of coal, we have to burn about 750 lb. per hr. At 50 lb. per sq.ft. per hr., which is really a low figure with intense draft, we need about 15 sq.ft. of grate surface.

With narrow gas passages and close contact with the heating surface it is necessary to get complete combustion of the gases before they come in contact with the

boiler shell or tubes, once in contact and the temperature reduced, combustion cannot be completed, and to accomplish desired results we must, therefore, provide a proper combustion chamber.

Under the required draft conditions, neither a dutch-oven nor any of the ordinary arrangements with arches, bridges, etc., would serve the purpose, as the gases would travel at such a high velocity after leaving the bed of coal on the grates, that there would not be time or chance for thorough mixing or complete combustion before they come in contact with the heating surfaces. Under such conditions nothing but a checker work of heated bricks would do, and the only device the writer has seen so far that would promise a solution of this essential problem is the "Broman" perforated arch furnace, described in POWER, Feb. 4, page 171.

As seen from Fig. 1, this proposed setting provides a large combustion chamber without sacrificing any of the most effective part of the heating surface and brings the gases in very close contact with the shell. In passing through the numerous small openings the gases are divided up into such small volumes and brought in such intimate contact with the free air that it seems complete combustion would be the inevitable result. After complete combustion has once been accomplished the next problem is to bring the gases in as close contact with the shell as possible. For the remaining part of the shell this could be done by building two or three bridges, such as A, back of the oven, the top of these to conform with the curvature of the shell, the space between the bridge and boiler depending on the intensity of the draft; the higher the speed of the gases the less the space.

To obtain as long a passage as possible the boiler should be made longer than the usual standard, if space permits, and the tubes of much smaller diameter, not over 2 in.

In regard to spacing of tubes, the author believes the method of staggering them, universal 25 or 30 years ago, is the most effective when it comes to rapid heat absorbtion.

As the circulation is more or less in a vertical direction, a glance at Figs. 2 and 3 will tell at once which construction is the most effective. In Fig. 2 the body of water passing down between the tubes, strikes the hottest part of the tube below and splits up in two directions, sweeping the entire surface of the tubes. This is not the case in Fig. 3, however. Being a liquid and not subject to expansion, it cannot fill the larger space, as at A, if the rate of flow is uniform, and the result is poor heat transmission over what should be the most effective surface and corresponding high stack temperature.

With still higher rate of combustion, say, 80 or 100 lb. of coal per hour per square foot, it may be found advisable to have a two-pass boiler, as shown in Fig. 4, or some simple economizer arrangement made up of piping and boxed in so as to be easily blown out with steam. With proper draft there is no reason why we should not get 250 or 300 hp. out of a boiler of this size, at as high, if not higher, efficiency than is now obtained with the ordinary arrangements.

❋ ❋

Power Equipment of the "Aquitania"*

SYNOPSIS—The vessel is considered the queen of the Cunard fleet. She has 21 doubled-ended boilers. The turbines work on the triple-compound system, giving a great range of expansion. The steam piping is most complete. A Diesel engine-generating set on the boat deck will furnish light in emergencies.

❋

On Apr. 21, the new Cunard liner, "Aquitania," was launched at Clydebank, England. This vessel is 902 ft. long, 97 ft. beam, with a hull depth of 64 ft., and a displacement of 49,000 tons. It will be propelled by four screws driven by steam turbines, giving a total of 60,000 shaft-horsepower. The boilers are double ended, with a total heating surface of 139,000 sq.ft.; grate area, 3500 sq.ft., and they will operate at 195 lb. pressure. The vessel is built for 23.5 knots per hour. Fig. 1 shows the hull in course of construction.

This vessel was patterned after the "Lusitania" and "Mauretania," but new features are added, increasing the safety and general utility of the vessel. The "Aquitania" is larger in length, beam and tonnage than the "Lusitania," but is less in horsepower by 8000; less in boiler-heating surface by 19,350 sq.ft., and less in grate surface by 548 sq.ft. She is also 2.5 knots slower.

In the "Lusitania," the ratio of heating to grate surface is 36.7 : 1, and in the "Aquitania" 39.7 : 1. The ratio of indicated horsepower to grate surface is 17.14 : 1 for the "Aquitania" and 16.8 : 1 for the "Lusitania." It is thus seen that the "Aquitania" has much reserve power.

*Acknowledgment is made to the Cunard Co., and "Engineering" (London) for the information herein contained.

BOILERS

There are 21 double-ended boilers, with eight furnaces in each; the working pressure is 195 lb. per sq.in. All boilers work under forced draft, the air pressure being maintained by twenty-eight 66-in. fans, driven by 14 electric motors, one motor driving two fans.

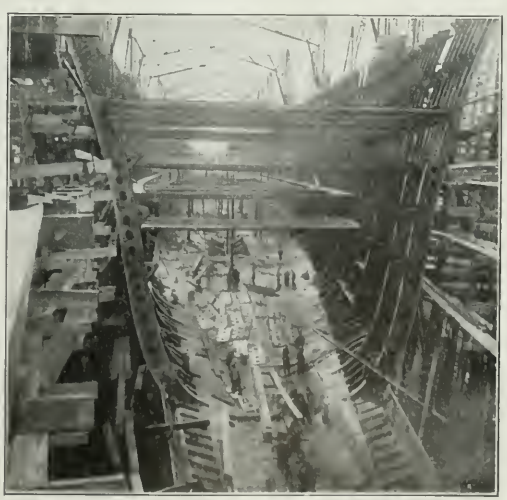


FIG. 1. HULL DURING CONSTRUCTION

There are four boiler rooms. In each of the three forward boiler rooms, which are 78 ft. long by 60 ft. wide, are six boilers, placed three abreast, while in the aftermost boiler room, which is 42x60 ft., there are three boilers similarly placed. In addition to the ordinary exits, there is an emergency escape from each boiler room through the deck overhead.

To each boiler room, there is a large double-elliptical funnel, the outer casings of each being 24 ft. on the major axis, by 17 ft. on the minor axis. The forward funnel is 154 ft. 9 in. above the fire grate, and 64 ft. 6 in. above the casing top. The firing platforms are clear at all times, as the ashes are expelled by machinery. In addition to these expellers, eight ash hoists are distributed throughout the boiler rooms.

Turbine-Propelling Machinery

The turbines are arranged in three engine rooms, one in each wing, and a center compartment, divided by longitudinal bulkheads. The total length of the engine room is 84 ft.

The turbine arrangement is somewhat different from that in the "Lusitania." In the latter, the system of compound turbines—one high-pressure exhausting into one low-pressure turbine—was adopted, there being two complete and separate units on each side of the center line of the ship. In the "Aquitania," however, the turbines are arranged to work on the triple-compound system, which gives a greater range of expansion, and, consequently, a higher economy. The port-wing shaft is rotated by the high-pressure turbines, which exhaust into an intermediate-pressure turbine on the starboard-wing shaft, the steam goes thence through a pipe leading into two low-pressure turbines mounted on the inner shaft. The steam-piping arrangement in connection with the operation of this triple arrangement is such that the high-pressure turbine may be cut out at will in the event of an accident, the steam passing direct from the boilers to the intermediate-pressure turbine on the starboard shaft.

In the event of its being necessary to cut out the intermediate-pressure turbine, the boiler steam will pass to the high-pressure turbine on the port-wing shaft, and thence to the low-pressure turbine on the port inner shaft, while the starboard low-pressure turbine could be driven by boiler steam, passed direct through the lead provided for the running of the low-pressure turbine when maneuvering. If the low-pressure turbine on the starboard inner shaft should be placed out of action, the high-pressure, the intermediate-pressure and the other low-pressure turbine could be operated, a blank flange, provided for the purpose, being fitted in the connection between the intermediate-pressure turbine and the starboard low-pressure turbine. Thus, if any one turbine is disabled, the other three shafts can be worked with little loss of time in making the changeover. Considering the capacity for overload of all the turbines, the speed of the ship need not be greatly reduced. The turbine arrangement is considerably better than that of the twin-screw ship, where, if the machinery on one side breaks down, the ship can only be propelled by the machinery on one side of the center line.

Main Steam Piping

As on all large ships, there are two main steam pipes between the boiler and the engine room. Both are in direct communication with the main line of piping at the forward end of the engine room. In this line are interposed separators, the usual stop valves, these being so located that the steam may pass directly into the high-pressure turbine or, alternately, directly to the intermediate turbine, while an independent line of piping is led to each of the two low-pressure turbines, the main object being to utilize these pipes for maneuvering in the harbor or at docks. At sea, and whenever required, all four propellers can be utilized for astern working, each shaft being fitted with an astern turbine. On the wing

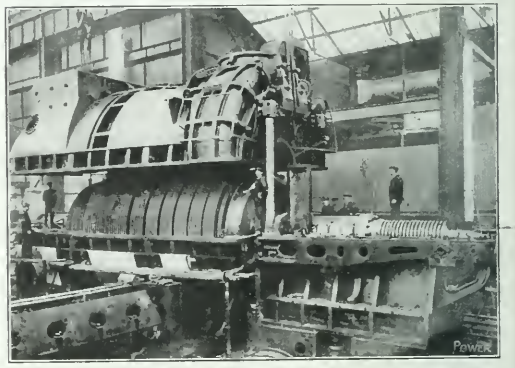


Fig. 2. Low-Pressure Ahead and Astern Turbine of "Aquitania"

shaft are mounted high-pressure astern turbines abaft and separate from the ahead turbines and to these there are direct lines of steam pipes.

Low-pressure astern turbines are arranged in the same casing as the low-pressure ahead turbines on both inner shafts. The port astern high-pressure turbine passes steam directly to the low-pressure astern turbine on the port inner shaft and the starboard astern high-pressure turbine to the low-pressure astern turbine on the starboard inner shaft. All steam-admission or maneuvring valves and the bulkhead valves are operated by levers from a platform on which the engineer on watch must stand. He, therefore, has full control of the engine room. On the high-pressure turbine-exhaust line to the intermediate-pressure turbine a 53-in. change valve is introduced, by which the high-pressure ahead-turbine exhaust can be passed either to the intermediate-pressure turbine or directly to the low-pressure ahead turbine.

A 66-in. shutoff valve is fitted in the line of piping between the intermediate-pressure turbine and the low-pressure turbine, so that, when this valve is closed, the intermediate-pressure turbine exhausts through the starboard low-pressure ahead turbines only, and the high-pressure turbines exhaust into the low-pressure turbine on the port shaft only. This means that, should the low-pressure turbine on the port inner shaft get out of order, the ship could be propelled by the high-pressure turbine on the port-wing shaft, the intermediate-pressure turbine on the starboard-wing shaft and the low-pressure turbine on the starboard inner shaft. There is a separate boiler-steam connection to the intermediate-pressure turbine so that, if the shutoff valve on the intermediate-pressure exhaust pipe is closed, the intermediate-pressure turbine and the

low-pressure turbine on the starboard side can be worked independently of the high-pressure turbine and the low-pressure turbine on the port side.

Under these conditions, the port shaft may be working ahead while the starboard shafts are running astern, or *vice versa*. The high-pressure astern turbine is fitted abaft the high-pressure ahead turbine on the port shaft. These two turbines, when coupled together, make a total length of 63 ft. The bearing block between these turbines is fixed, the forward and aft ends being free to take up the expansion. The high-pressure astern turbine fitted abaft the intermediate-pressure turbine on the starboard-wing shaft is similar to that on the port-wing shaft. The main eduction, or exhaust pipe to the condenser of the low-pressure ahead and astern turbine is rectangular and 15 ft. wide by 6 ft. high. Fig. 2 shows one of the low-pressure ahead and astern turbines with the upper part of the casing removed, showing the rotor. The rotor of this turbine is shown in Fig. 3, and weighs 130 tons. The blades of the turbines are fitted in segments on the rosary principle, and are sharpened away at the points like a gouge.

On the after-turbine coupling, on each line of shafting, a motor-driven turning gear is fitted. All the casing covers have motor-driven lifting gears, the lifting beams being built into the ship and supported by the guide columns at both ends of the casing. The tunnel shafting is hollow and divided into lengths of about 25 ft. each. There are two bearings to each length. All the shafting and the rotor drums were made by John Brown & Co. The rotor drums are of forged steel and are sprung out from an ingot previously trepanned. The turbine casings

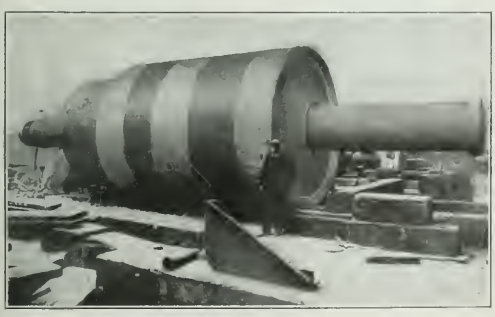


Fig. 3. Rotor of One of the Two Low-Pressure Ahead and Astern Turbines, Blading Is Covered

are of cast iron. Each low-pressure turbine exhausts into a Weir "Unilux" condenser. Two 30-in. discharge pipes from two centrifugal pumps supply the circulating water to each condenser.

The forced-lubrication system is very complete, there being six main forced-lubrication pumps in the center engine room, and, in connection with these, are the necessary strainers and coolers. All the tunnel blocks have forced-lubrication connections.

Each wing of the engine room contains two evaporators, each of 75 tons capacity per 24 hours.

Electrical Installation

The generating machinery for the electrical installation will consist of four British Westinghouse Co.'s impulse turbines, each driving a 225-volt, 100-kw., three-wire direct-current generator at 1500 r.p.m. The current on each side of the circuits will be balanced or compensated for by a static transformer in conjunction with slip rings on each turbo-dynamo. In addition to the main generators, a Mirrlees Diesel oil engine driving a 30-kw Westinghouse generator will be placed in a house on the boat deck and will be available for emergency purposes.

There will be a total of about 200 motors, ranging in horsepower from 60, for the stokehold-fan motors, to ¼ hp. All elevators, lids, winches, etc., will be motor driven, for lighting the ship, about 7000 electric lamps will be installed. As far as is practicable, these will be of the metallic-filament type.

Refrigeration Plant

The refrigeration plant will be used solely for the cuisine department, as no refrigerated cargo will be carried. A compound duplex refrigerating machine with two CO_2 compressors, two independent evaporators, duplex drying pumps and circulating pumps are being fitted to cool the many large compartments in which the ship stores are carried. The "Aquitania" and its turbines were built by John Brown & Co., Sheffield, England.

Japanese as Electrical Manufacturers

It is the ambition of Japanese engineers to make their country the workshop from which a great part of Asia will draw its requirements in respect of electrical and other machinery, declares the London *Times*, and it does not appear to be realized by European manufacturers that already the diligent imitative talent and the energetic enterprise of the Japanese have established important works of this character.

There is no sign as yet that Japan will contribute anything toward the progress of engineering science and invention, and the protective policy aims rather at providing the means whereby the new ideas of European and American engineers may be readily adopted as soon as their value is proved. For repetition work the low cost of Asiatic labor may or may not become a powerful competitive influence, but as there appears to be no reason why nearly all the generating and distributing electrical plant and apparatus needed for the Japanese home market should not be manufactured locally, the attention of outsiders may preferably be directed in the near future to the prospects on the mainland.

China has already made a start with engineering works in connection with the railways, and it will perhaps be necessary before long for Western enterprise to come to a decision as to whether financial and commercial control should be acquired of the infant electrical factories that will come into being.

These new publications are announced by the Bureau of Mines and may be had by addressing the Director, Bureau of Mines, Washington, D. C., and ordering by number: Bulletin 48. Selection of explosives used in engineering and mining operations, by Clarence Hall and S. P. Howell. 50 pp., 3 pls., 7 figs. Bulletin 55. The commercial trend of the gas producer in the United States, by R. H. Fernald. 92 pp., 1 pl., 4 figs. Bulletin 62. National Mine-Rescue and First-Aid Conference, Pittsburgh, Penn., Sept. 23-26, 1912, by H. M. Wilson. 74 pp. Technical Paper 38. Wastes in the production and utilization of natural gas, and means for their prevention, by Ralph Arnold and F. G. Clapp. 23 pp. Technical Paper 48. Coal-mine accidents in the United States, 1896-1912, with monthly statistics for 1912, compiled by E. W. Horton. 72 pp., 10 figs.

Engineer's Annual Report

By C. T. McChesney

It is an excellent practice to gather yearly all the statistics and general data available relating to power-plant operation, and formulate them into a general report, using only such facts and figures from the weekly reports as are of most importance to a yearly operating statement.

It is the business of the chief engineer to undertake this work, so that his employers may annually have a statement of results for comparison with previous years, comparison with plants of approximately similar size and as a guide for future expansion and endeavor.

First, the report should contain a brief summary of the power-plant equipment, as, for instance:

Boilers:

4 Horizontal-tubular boilers, shell 54 in. x 14 ft. Built 1897. Insured for 100 lb. pressure.
1 Chimney, 56 in. diameter x 110 ft. high.

This tabulation is to be carried through all departments. It will be found that information thus accumulated and set forth will frequently prove useful. It is well to start with the engine-room units by designating them by numbers, location or use. Thus:

Unit No. 1. Blank Co.'s automatic,
16x18 in., 250 r.p.m., directly connected to
125-kw. X X generator.
Piston rod $2\frac{1}{2}$ in. diameter.
Hp. = 3.92 × mean pressure.

It is assumed that weekly indicator diagrams have been taken from each unit. Representative diagrams should be selected and incorporated in the report. They will disclose the nature of the valve setting, and give an idea of the back pressure on the engine, vacuum maintained, loss of pressure in the steam line and a hint as to the tightness of the valves and pistons. Explanatory notes may be written on the diagrams regarding the condition of the valve-gear, etc.

Results of Tests

If weekly power determinations have been made, they may be stated about as follows:

Department . . Unit No. 1			
Date	Sets of Cards	Indicated Horsepower	Load
1—2—12	6	200	Machine or switchboard readings.

An abbreviated statement of boiler evaporation or capacity tests should be incorporated in the report, as follows in an assumed case:

BOILER TESTS AT BUILDING A

Trial No. . .	100
Duration, hr. .	10
Steam-gage pressure, lb. .	75
Draft at damper, in. . . .	0.40
Temperature of feed water, deg. F. . .	182
Temperature of chimney gases, deg F	480
Kind of coal used . .	Bituminous
Moisture in coal, per cent.	3
Wet coal used, lb.	10,000
Dry coal used, lb. .	9,700
Dry ash and refuse, lb.	850
Dry asb and refuse, per cent.	8.8
Dry combustible, lb.	8,850
Water evaporated, lb.	90,000
Water evaporated at and from 212 deg. F. per pound of dry coal, lb.	9.83
Water evaporated per lb of combustible, lb. . .	10.80
Boiler horsepower.	280

Note: In calculating the foregoing boiler trial, let
t = Temperature of feed water, deg. F.;
H = Total heat of steam at the boiler pressure above 32 deg. F.;
W = Weight of water actually evaporated.

Then the equivalent evaporation from and at 212 deg. F. equals

$$W = \frac{H - (t + 32)}{965.7}$$

The percentage of ash equals the weight of ash multiplied by 100 and divided by the total weight of dry coal used.

A summary of the total amounts of raw materials used in the operation of the plant for the year, and their costs, together with labor and wages should also be tabulated as assumed herewith.

Thus:

Power Dept. of Bldg A

Year	1910	1911
Quantities:		
Days mill ran.	300	300
Boiler hp.	265	280
Engine hp.	185	200
Kind of coal used.	Pocahontas	Bituminous
Coal used, tons.	2000	1900
Cylinder oil, gal.	200	190
Machine oil, gal. . . .	225	210
Costs:		
Total for coal, $2.90 per ton.	$5,800	$5,510
Ash removal (25c. per ton). . . .	45	42.75
Cylinder oil (35c. per gal.) . .	70	66.50
Engine oil. . .	68	65
Waste, packing and other supplies.	100	100
Boiler compound. . .	50	25
Boiler insurance per year. . . .	15	15
Fire insurance.	20	20
Repairs. . .	390	400
Taxes on power plant. . . .	45	45
Engineers, firemen and coal passers, wages.	5,500	5,500
Yearly cost.	$12,103	$11,789.25
Power cost per engine-hp. per year, not including steam used for nonpower purposes.	$65.42	$58.95

These estimates do not include any charges for depreciation and interest on money invested in the power plant.

Lastly the engineer may prepare a table of coal and power costs per unit of production of his plant. This will be a tabulation that will interest his employer, and is the only fair manner in which to judge the economy of power production.

Conclusions and Recommendations

A general review of the work of the year should be incorporated in the annual report. It need not be elaborate; merely a statement of facts that stand out clearly as important. After the general description of the plant, work that has been done on it, and all important information have been given, the engineer may proceed to give his recommendations for the future welfare of the plant.

It is a written plea from the man in charge to his superior, in which he asks that he be allowed to make certain changes or purchases. He may thus demonstrate by his report that such and such a line of action is advantageous, and he may show in this manner that he is a capable, wide-awake engineer.

❖

Professor Huxley, the celebrated scientist, could not be accused of undervaluing science, but he never lost sight of the fact that practical work kept the world moving. In addressing the students of a scientific school he once took occasion to urge the necessity for combining skill in handicraft with technical knowledge. All his life he had been trying to persuade people that, if they wanted to teach physical science, it was no use to proceed by filling the minds of the students with general propositions which they did not understand, from which they were to deduce details which they comprehended still less. The learned professor spoke of the advances made in providing scientific education for artisans and anticipated that progress in this line was destined to become very rapid, all of which has been verified.—"Railway & Locomotive Engineering."

The Kingsbury Thrust Bearing

The design of the Kingsbury thrust bearing consists in general of a collar rotating with the shaft and sliding on stationary parts arranged to receive the thrust, the whole being flooded with oil. The bearing somewhat resembles the ordinary collar-thrust bearing used on line shafting, etc., but it differs from the common type in one essential feature, as described below:

In the ordinary collar bearing the stationary bearing surface is provided by a continuous ring, while in the Kingsbury bearing this ring is divided into several independent sectors or "shoes," generally six in number. These shoes are shown at *A* in the photograph.

Each shoe is so supported against the thrust that it may independently align itself to the different conditions of bearing surface. This self-adjusting feature is provided by rounding the supporting surface or seat of the shoe, so that it may rock or pivot over its central area. The seat of the "shoe" is shown at *B* in Fig. 1 and at *C* in Fig. 2.

The bearing here shown is such as is used in the 10,000-kw. vertical generating units, load 410,000 lb., speed 94 r.p.m., at the McCalls Ferry plant of the Pennsylvania

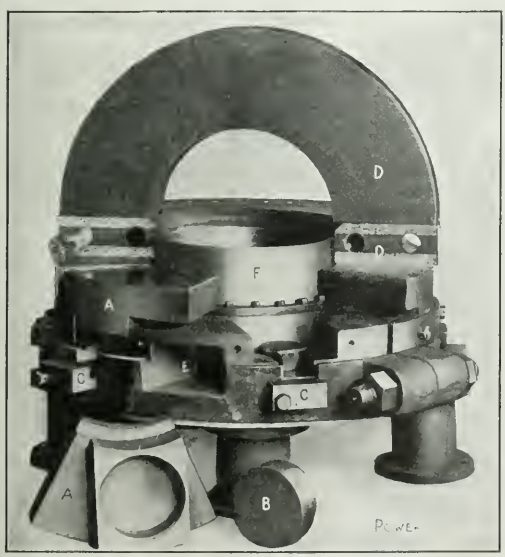


Fig. 1. Kingsbury Thrust Bearing Partly Disassembled

Water & Power Co., and referred to in this issue on page 658 of the article describing that plant. Tests were made of the bearing at this plant and the following data obtained:

Outside diameter of collar, inches	48
Total load on bearing, pounds	410,000
Area of shoes, square inches	1,160
Unit pressure per sq.in., lb	350
Revolutions per minute	94
Mean surface speed, ft. per min.	900
Oil flow through bearing per min. gal	15
Kind of oil	light mineral
Mean temperature rise of oil in bearing, deg. F	4.5
Frictional loss in bearing, hp.	9
Coefficient of friction	0.0008

For large bearings, such as the above, each shoe is provided with adjusting wedges *C*, Fig. 1; *D*, Fig. 2, for equalizing the load on the "shoes." The runner *D*, Fig. 1, revolves with the shaft and on an oil film between the runner and the "shoes." In Fig. 1, *E* is an oil-inlet passage and *F* is the inside oil-retaining ring. Half of the runner is here shown in section, the other half being stood on ends to show the construction.

The shaft collar, Fig. 2, is generally made of cast iron or mild steel, the shoes of cast iron or cast steel and faced with babbitt metal. For very heavy loads at slow

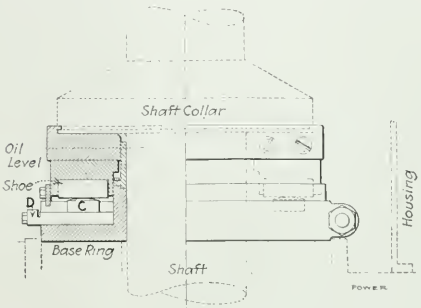


Fig. 2. Partial Sectional Elevation of Kingsbury Thrust Bearing

speeds a harder material than babbitt is used, such as chilled cast iron or hardened steel with brass or bronze shoes. The bearing is made in halves when required to allow of assembling it without disturbing the shaft collar.

As applied to steam turbines, this bearing ordinarily carries 500 lb. per sq.in. as a maximum, the linear speeds being 3000 to 4500 ft. per min. For vertical waterwheels and similar work the pressure is from 250 to 400 lb. per sq.in., the coefficient of friction lying between 0.001 and 0.002.

Tests have shown that this bearing practically has no limit as to speed so long as there is a good circulation of oil. Tests for overload capacity have been made on a bearing running at 3600 r.p.m., 4500 ft. per min., on which the load was gradually increased from 800 to 10,000 lb. per sq.in. without causing failure of the oil film. At 10,000 lb. the pressure was sufficient to crush the babbitt metal, causing it to flow laterally in all directions.

The bearing was invented by Albert Kingsbury, of Pittsburgh, Penn.

Dundee Falls Development

At Dundee Falls, Maine, on the Presumpscot River, a new power station for the S. D. Warren Co., paper manufacturers, is being erected under the general supervision of the Stone & Webster Engineering Corp. The dam structure, about 1400 ft. long, is of earth, with the power house and spillway of reinforced concrete nearly in the center. The head is to be 50 ft., with a wheel capacity of 1500 hp. The concrete spillway is of the gravity-suction type.

Power will be supplied by three 33-in. horizontal turbines of the wicket-gate type, each capable of developing 1500 hp. at 277 r.p.m. Each wheel is direct connected to an 800-kw. generator operating three-phase at 60 cycles per second, and at a pressure of 11,000 volts. In each case the exciter is on an extension of the generator shaft.

ELECTRICAL DEPARTMENT

Electric Elevator Questions and Answers

By A. C. Waldron

Name some causes for magnetic-control elevators not starting.

The car may be down so low that the counterweights have come against the limit switches at the top of the well, which breaks the circuit and throws out the circuit-breaker. Most electric elevators are supplied with two spanner wrenches which fit round the brake-wheel hub, and by slightly relieving the tension on the brake band, the motor can be turned. This will raise the car and lower the counterweights away from the limit switch. If there are two sets of counterweights and the brake tension is completely relieved, the elevator will race to the roof, sometimes unaided.

Another way is to put a screwdriver in the limit switch while it is open; this will close the circuit and the car can be moved.

Another cause for the car not starting may be the ropes riding over each other on the lifting drum, this extra thickness of rope bearing against the "slack cable" device, underneath the drum, and tipping it, which breaks the circuit and cuts off current to the motor. The remedy is to use the spanner wrenches, as before, to wind the rope until it is running right.

If the electrical contacts are not kept clean and bright the car will not always start. If the car is above the top floor about two feet it it will come against the limit switch and cut off all current. In this case it is easier to use spanner wrenches to slacken the brake band and bring the car down enough to allow the limit switch to close.

Blowing of fuses will, of course, stop the car and throw out the circuit-breaker.

What will cause a car to run past floors?

If there is a short-circuit in the controller it will arc from one contact to another, and cause the brake to hold up.

Remedy: Remove the burnt nonarcing baffle-plate and replace it with a new one. Also if the tension on the brake spring is slack or the brake band is hot it will cause the car to slide. Having put too much soap on the brake pulley will cause the car to slide by floors.

What causes a solid stop on the up trip?

If the top brake band is too tight it will jounce the car. The remedy is to take out the bolt in the brake band and give the screw-eye half a turn less. If a solid stop occurs on the down trip, take out the bolt on the bottom brake band and slacken up a half turn. Never take out both bolts at once unless a timber is put in the main-rope drum wheel, because the car will run away to the roof.

What care should be given electric elevators in general?

Watch the ropes for stretching, especially the car counterweight ropes. Do not allow the weights to bang on the basement floor as they are cast iron and are liable to break. They should be taken up in six or eight months, depending on the quality of rope used.

How should a rope be inspected?

When the rope passes over the sheaves at the top of the elevator well, have the operator run the car two feet at a time, and broken wires can be plainly seen and examined.

How many broken wires are considered dangerous?

The writer has seen as many as 15 broken wires in a length of 2 ft., this instance being in one of the busiest and largest office buildings in Boston. Ropes are frequently kept running a long time with many broken wires if they do not occur in a short distance from each other.

Where should one look for the greatest number of breaks in a rope?

In the back drum counterweight ropes, because this frequently has twice as many sheaves to run over, making twice as much bending. Attention should also be paid to the worm gear, which is extended from the motor shaft, and the gear casing should be kept half full of oil, preferably castor oil. The automatic feeding grease cups on the traveling sheave over the main drum should be kept full. If they are not, the sheave will refuse to travel and will ride the ropes over one another, in which case they are liable to run off the sheave.

How may a loaded car be started after the safety devices have set?

The first thing to do is to get the passengers out. If this is impossible, assure them that all will be well if they remain quiet. Then see if the lifting ropes are slack. If they are, take the spanner wrenches and turn the motor or brake shaft enough to tighten the lifting rope so as to hold the car and its load. Then get into the car and take up the small, round, floor plate and with a socket wrench, unscrew the safety very easily. If the safety is slackened sufficiently, the elevator will hang normally on the lifting rope. Next, go to the top of the elevator well and throw back the safety lever, which will throw out the safety-governor clutch so that the car can be run. In case the stoppage is between floors, take the spanner wrenches and lower the car to the nearest floor to let off the load, after which put the safety rope back in the ball clutch on the top of the car; then operate the car from the switchboard controller for several trips to see that everything is in good order before anyone gets into the car.

What care should be given the safeties?

Every month raise the car above the basement floor, get under it and pull the rope that is wound up on the safety-clutch shaft. This will set the safeties, and keep them in good working order. Then get into the car, take up the round floor plate and with a socket wrench as previously mentioned slacken up on them until they do not drag.

What care should be given the guide rails?

Both the car rails and the counterweight rails should be scraped and oiled once a week to keep the car shoes from

rubbing hard on the guides. An excellent lubricant consists of one quart of cylinder oil and half a pint of flaked graphite, in warm weather, while in cold weather, there may be added red engine oil to give the proper consistancy. If the babbitt in the car shoes is badly worn and causes grating, a graphite candle, held on each side of the rail for a few trips, will stop grating; or, the shoes may be slackened so that they will not jam against the rails. Jamming is bad, both on the car rails and on the counterweight rails, because it wears them to a sharp burr edge, necessitating treatment with a file.

Care should be taken in using the proper lubricant on the overhead sheeves, because a grease that will do in winter will not always give satisfaction in the summer, and *vice versa*. Many a passenger has got a new suit or a dress soiled because of a drop of lubricant from the bearings of the overhead sheeves. Let the attendent keep the drip pans empty and this will not happen.

Why are two sets of counterweights used on an electric passenger elevator?

One set is to nearly balance the car. This set usually is above the other. The bottom or back-drum counterweights are fastened by cable around the rope-drum wheels and weighted to counterbalance the average passenger load. This lessens the load on the motor when the car is carrying normal load; hence when the car is lightly loaded, it takes more current (on the return trip) than when a fair load is carried, because when a fair load is carried, if the back-drum counterweights are of the proper weight, the motor simply slides along. With no load the car tends to run away to the roof if the brake is lifted, or becomes disabled.

Alternating-Current Conductors

By Clifford R. Parliman

The tendency of alternating current, when transmitted along a conductor, is to travel in concentric circles. Take, for an example, the cross-section of a round, solid-copper conductor, Fig. 1, as a graphical explanation of current travel. We are given to understand by Steinmetz and other investigators that the current density at the center of such a conductor is at a minimum and gradually increases toward the periphery. Its density, therefore, attains a maximum value at the periphery; causing what is technically known as a "skin effect."* The result, however, of overloading a conductor is leakage, as presented at *A*, Fig. 2; this is proportional to the overload. The current density, nevertheless, would still be greater at the periphery.

Assuming that this theory of alternating-current transmission is correct, then surely there is an unnecessary waste of material at the core, when the proportionate carrying capacity of a cross-section is considered.

Another bad feature of such a conductor is that as the circumfluent current density becomes a maximum at the periphery, the conductor is susceptible to overheating. Both of these faults, however, can be obviated by a hollow conductor, as in Fig. 3, where the proportion of orifice diameter *C* to the thickness of walls *T* is as 2:1. It is evident that with a larger exposed surface (*F* and *F'*) the cooling conditions of this hollow conductor will be greatly improved over that of the solid one, also the current density would be more evenly distributed over the cross-section.

It might be mentioned that the New York Edison Co. is planning to experiment upon the use of hollow busbars in one of its large stations.

*Skin Effect—see Foster's Hand Book.

Quick Restoration of Service

During the last week in March, Columbus, Ohio, was inundated by the Scioto River and for over two days the main generating units of the Municipal Lighting plant were under water. After the water went down the generators were dried out by running them with the armatures short-circuited, in the usual manner. On Saturday afternoon, however, Apr. 12, a shirt-circuit developed in the leads to two of the turbo-generators, one a 1000-kw. and the other a 2000-kw. machine. These dead shorts followed the leads into the high-tension stator windings, which were so badly damaged that the two machines will have to be rewound. The branch office of the Allis-Chalmers Co. in Cleveland received notification of the accident on Monday afternoon and the information was immediately wired to the factory in Milwaukee. The generator end of a 1000-kw. unit was in stock. This was loaded and shipped from the factory on Tuesday, and by Thursday evening it had been connected up and was able to carry a part of the load on the station.

Fig. 1

Fig. 2

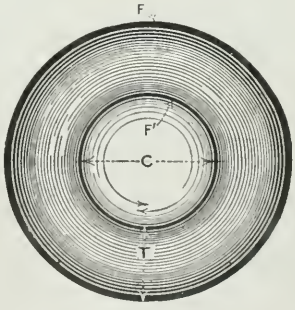


Fig. 3

GAS POWER DEPARTMENT

Dust Determinations for Blast-Furnace Gas

By Everard Brown

There are several methods employed for measuring the amount of flue dust in blast-furnace gas. Where such gas is used for gas engines, knowledge of its dust content is essential, because it permits of careful surveillance of the gas-cleaning plant and its efficiency. That all blast-furnace gas must undergo a thorough cleaning before it is introduced into the engine is, of course, understood.

In making determinations of this kind the method of taking the samples is of prime importance. In the first place, the samples should be taken from the gas main at a point between the last or final cleaning apparatus (several stages of cleaning being necessary to make the gas suitable for use in internal-combustion engines) and the engine, at least 12 or 15 ft. from any bend or constriction, in order that the current of gas may be free from local disturbances.

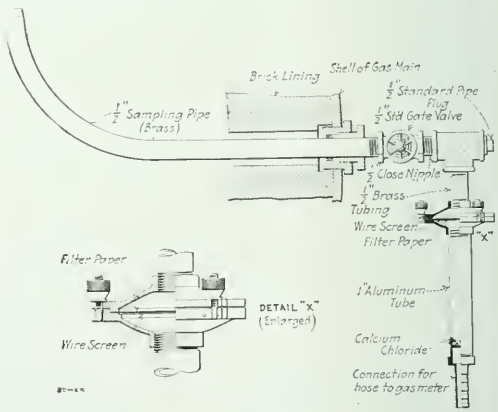
The sampling pipe should be of hard-drawn brass, which, because of its polished internal surface, affords the least opportunity for dust accumulation. A half-inch tube is sufficiently large for the purpose, bent to any convenient radius but not less than 6 in., so that it can be inserted in the main with its entering end pointing against the current of gas. It is important, however, that the bent portion within the main be parallel to the sides of the latter so as not to change the direction of flow nor impede the progress of the gas. Moreover, it is advisable to reduce the walls of the brass tube at the entering end to a sharp edge so there will be as little disturbance of the gas as possible at this point. Wherever possible the sampling pipe should be inserted on the horizontal diameter of the gas main and should extend into the stream of gas from one-fourth to one-third of the internal diameter of the main, in order to secure a representative sample. There appears to be some difference of opinion on this point, however, the contention being that with a fairly clean gas it is not necessary to extend the pipe further than a few inches beyond the lining of the gas main. The necessity for bending the sampling pipe so that its entering end will face the current is also doubted by some; nevertheless, it can do no harm and might possibly do some good. With gas that was not thoroughly cleaned, for instance, it would be rather difficult, even with artificial suction, to overcome the inertia of the heavier dust particles and cause them to change their direction and enter a pipe that sticks straight into the gas main, whereas with a curved sampling pipe this would not be necessary.

In taking any gas sample for the purpose of determining the amount of its suspended matter, it is desirable to maintain, as nearly as possible, a velocity in the sampling pipe equal to that in the gas main itself. This is rather difficult, however, because there is sure to be some retardation within the former. Various devices, such as siphons and other inductive agents, have been tried to increase the velocity in the sampling pipe, but as far as the writer knows the success of these has been doubtful.

Probably the most common method employed in making flue-dust determinations consists in filtering the blast-furnace gas through a tube packed with absorbent cotton. This method is rather crude, however, and is subject to many chances for error. In fact, the simplicity of the apparatus involved is about all that commends it.

In the first place, this method is hardly practical for checking up the efficiency of operation of a gas-cleaning plant because of the long period required for each individual observation and also because of the great amount of time taken up in drying and weighing the cotton. This means that probably not more than one determination can be made each day.

With the use of absorbent cotton as a filtering medium it is necessary to first thoroughly dry it over phosphorus pentoxide or calcium chloride, after which it must be carefully weighed and packed in its glass container. Then,



Details of Sampling Tube

when a certain quantity of gas has passed through, this cotton must be again thoroughly dried and weighed, the difference in weight determining the amount of dust and impurities contained in the sample of gas passed through. This process not only requires considerable time, but also skill and attention, because of the highly hygroscopic character of the filtering material. Furthermore, in packing the cotton into the glass tube, there is another source of error on account of the practical impossibility of two operators to so pack the cotton as to get the same homogenity of filter, without crevices and channels through which particles of the gas might pass unfiltered. This also holds true of one operator preparing a number of filters.

Another method of making flue-dust determinations consists in first passing the gas through several U-tubes filled with glass pearls for condensing the moisture and then through glass-wool as a filtering medium. This

method has an advantage over the previous one in that glass-wool is not so highly hygroscopic as absorbent cotton. Perhaps another advantage is the ability to weigh the glass tubes, including their filling, on a chemical balance. The disadvantage of the method is the care necessary in handling this bulky apparatus.

Twelve or fifteen years ago an entirely different method of determining the amount of suspended matter in blast-furnace gas was brought out by Leo Martins, of Germany, whereby ordinary Swedish filter paper is used as a filtering medium. The accompanying sketch shows the apparatus in slightly modified form, which seems to be an improvement over the original construction.

The filter paper, which is about 5 in. in diameter, is contained in a conical-shaped, metallic receptacle made in two parts to permit of the ready insertion and removal of the paper. The halves of this container are held together by three swing bolts fitted with thumb nuts so that little time is required to get at the interior. The paper itself is supported by a wire screen to prevent tearing, due to the pressure of the gas. The upper part of the apparatus is connected to the gas main and the lower to a wet-gas meter measuring the volume of the gas sample taken. In order to catch the moisture due to condensation of steam and vapors in the gas, a tube containing calcium chloride is attached to the lower part of the device, through which the sample must pass before it is metered. The reason for this is obvious, as it is not desired to take into account any moisture that might be contained in the gas. Furthermore, the whole apparatus is inclosed in a box, usually of wood, with an asbestos board lining, within which a sufficiently high temperature is maintained by means of an electric incandescent light or other device, to prevent condensation and accumulation of moisture on the filter paper.

The container for the filtering paper should be of polished brass so as to present as little adhering surface as possible for the gas. This will practically eliminate any error, due to precipitation of dust on the interior walls of the apparatus. For the same reason the inlet pipe should also be of brass. The tube containing the calcium chloride is usually made of aluminum and the rest of the connections of ordinary standard material. A hose should be used, however, to connect the lower end of the calcium-chloride tube with the gas meter so that there will be enough flexibility to allow the filter container to come apart by simply loosening the three thumb nuts and pulling down the bolts. The operation is as follows:

Before inserting the filter paper, it is thoroughly dried and carefully weighed. A sufficiently large sample of gas is then drawn through the instrument to assure an appreciable amount of dust on the filter paper, this quantity of gas being recorded by the wet-gas meter. All the dust and impurities contained in this sample are deposited on one side of the paper, which is then removed, dried and weighed again, the difference between the two weights being the weight of the impurities extracted and in turn the weight of the impurities per cubic foot of gas.

If the moisture content of the gas is also desired, which is most generally the case, the calcium chloride in the attached tube can be weighed before and after the sample is taken and the difference in weight will be the amount of moisture absorbed. If the gas contains a large amount of moisture, two of these tubes may be used.

This method of making dust determinations is probably the most satisfactory of all methods in use at present, as it has the advantage of being reliable and practically independent of the skill and ability of the operator. It also enables the chemist to make a number of determinations per day and if two instruments are used almost continuous records may be had.

It must be understood, of course, that the method described, or any other method for that matter, will not give as satisfactory results with raw gas that has received no cleaning as with gas sufficiently cleansed for use in a gas engine. This fact, however, does not necessarily reflect on the method itself because it is rather doubtful whether any apparatus could be devised that would take care of the very large quantities of flue dust in uncleaned blast-furnace gas.

Junkers vs. Diesel Engine*

Though not a Diesel engine adherent to the extent of failing to see certain fundamental advantages in the construction of the Junkers engine, I do not believe that some of the statements made by Mr. Junge in his discussion of this engine, will bear close scrutiny. First, the attempted comparison between the two engine types is entirely too broad for bringing any light whatever on the subject, and, second, the claims made with respect to the superiority of the Junkers engine are too broad.

Mr. Junge enumerates certain features relating to the combustion space and to the scavenging, which are regarded as necessary for obtaining the highest efficiency, and which unquestioningly are correct in principle; then he shows that the Junkers engine possesses these favorable features; and from that he concludes, without showing that the Diesel engine cannot equally well possess these features, that the Junkers engine must be the more efficient. The main proposition on which this higher efficiency of the Junkers engine is based Mr. Junge expresses thus: "For obtaining high efficiency it is necessary to keep the ratio of area to volume of the combustion space as small as possible. Of course, this is not to be taken literally. The least possible ratio of area to volume is possessed by a sphere, but the combustion space of the Junkers engine is not spherical. A cylinder possessing the least possible ratio of area to volume is one of a height equal to its diameter. If taken literally Mr. Junge's proposition would, therefore, mean that for obtaining the highest efficiency in an engine using a compression pressure of approximately 500 lb. it would be necessary to employ a piston stroke something like twelve times the cylinder diameter. The fact to which Mr. Junge's statement alludes can be stated briefly only by saying that when the compression is high the stroke of the engine should be somewhat long. The area of the surface confining the combustion space should, of course, be a minimum. It would not be impossible to design a Diesel engine of the type in question which would fulfill these conditions practically as well as they are filled in the Junkers engine.

Another proposition on which the claims for a higher efficiency of the Junkers engine seem to be based is that, because of the shorter crank radius of this engine, a higher piston speed can be used. This would be correct if all other conditions were the same, but not when comparing two engines of entirely different construction; it

*Discussion of a series of eight articles on the Junkers engine by F. E. Junge, which were concluded in the Mar. 25 issue.

all depends on the weights of the reciprocating masses. In the Junkers engine there are attached to the rear piston a piston rod, a heavy yoke, and side rods, with which the Diesel engine is not hampered. The question will then be: How much greater weight of the reciprocating parts may be allowed the Junkers engine, for equal smooth running at the same aggregate piston speed as that of the Diesel engine?

For smooth running (without backlash in the crankpin boxes) it will be required that the accelerating force on the crankpin shall not exceed a proper limit. Under normal conditions, as to the length of the connecting-rod, this force is

$$\frac{P}{F} = 0.000034 \frac{G}{F} N^2 r$$

where $\frac{P}{F}$ equals maximum accelerating force per square inch of piston area at the head end; F represents the area of the piston; $\frac{G}{F}$ the weight of the reciprocating parts per square inch of piston area; N the revolutions per minute, and r the crank radius in inches.

In the accompanying sketch the force $\frac{P}{F}$ is the distance AM and the line AB is the acceleration curve for the reciprocating masses. The line DEF is the adiabatic compression line for a compression to 500 lb. gage, and the dotted line GHB represents the resulting pressure between the bottom connecting-rod box and the crankpin, per square inch of piston area. If the numerical value of the negative accelerating force at I becomes so great as to carry the dotted line below the base line MN, it would indicate that backlash in the crankpin box will occur at that point.

To avoid this $\frac{P}{F}$ must not be more than, approximately, 0.4 of the compression pressure C, for a pressure approximating 500 lb. Hence,

$$0.000034 \frac{G}{F} N^2 r < 0.4\ C$$

Substituting $N^2 = 9 \frac{S^2}{r^2}$

where S = Piston speed in feet per minute;

$$\text{whence } S < K \sqrt{\frac{C r}{\frac{G}{F}}} \qquad (1)$$

K being a constant which varies with the compression.

Wishing to compare the limiting piston speed of the Junkers engine with that of the Diesel engine of the same diameter and stroke, we write

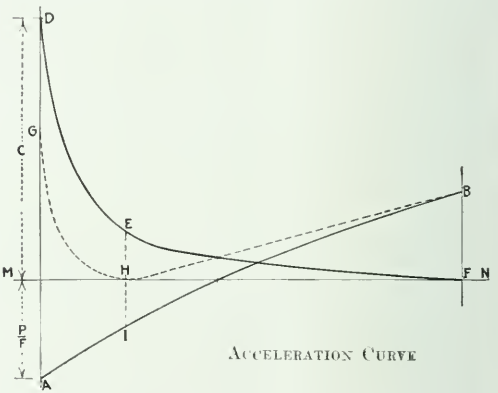
$$\frac{S_J}{S_D} = \frac{2\sqrt{\frac{C r}{\frac{G_J}{F}}}}{2\sqrt{\frac{C r}{\frac{G_D}{F}}}} = \frac{2}{1.41}\sqrt{\frac{G_J}{G_D}} \qquad (2)$$

S_J is the aggregate piston speed of the Junkers engine; S_D the piston speed of the Diesel engine; G_J and G_D the respective weights of the reciprocating parts.

For equal weights of the reciprocating parts the Junkers engine has, thus, with respect to the allowable piston speed, an advantage over the Diesel engine in the ratio of 2 to 1.41. This advantage may be lost, however, if its reciprocating parts are heavier than those of the Diesel engine; and equation (2) makes it evident that it is futile to discuss the question of allowable piston speed of the two types without considering the weights of their reciprocating parts.

That the scavenging of the Junkers engine must necessarily be more efficient than that of the Diesel engine because of any differences in the manner in which the air is admitted to the cylinder, cannot be taken for granted. It must be conceded, though, that an uncooled inlet valve of the Diesel engine may have some effect on the temperature charge, without greatly affecting the efficiency.

It is true that the rear cylinder-head casting of a single-acting engine appears complicated and has proved susceptible to breakage, but as far as the complication of the casting is concerned, it does not seem to cause any alarm in the uptodate foundry, and if properly designed it should not be more liable to break than any other part.



Acceleration Curve

Viewing the whole question in a broader sense the efficiencies of the two engines may be considered practically the same, there being no good reason for doing otherwise, until conclusive tests have proved such an assumption false. Then, disregard minor details, and we shall find that the essential features are as follows:

In the Junkers engine there are two sets of reciprocating working elements which practically balance each other, and there are no longitudinal strains in its frame, cylinder or cylinder connections; and this latter feature should not be considered lightly. In the Diesel engine the reciprocating elements are the simplest, but they are not entirely balanced, and there are heavy longitudinal strains in the framework that must be taken care of. The Diesel engine will, therefore, require a heavier foundation and a much heavier frame, cylinder-jacket walls and cylinder connections, than the Junkers engine. The Diesel engine may be said to have some advantage in that it can be installed more compactly as a two- or four-cylinder cross-connected engine. But as for weight there is no doubt but that the Junkers has the advantage.

A. M. Levin.

Chicago, Ill.

*Equation (1) may be written $S < K_1 \frac{C}{\frac{G}{F} N}$. For a compression pressure of 500 lb. K becomes approximately 3800 and for 100 lb., 7300. See the "Modern Gas Engine and the Gas Producer," by A. M. Levin.

HEATING AND VENTILATION

Some Notes on Ventilation

An interesting paper on ventilation was read recently by Arthur K. Ohmes before the Institute of Operating Engineers, of New York City. He told how difficult it is becoming to secure a supply of fresh air in large cities where the atmosphere is laden with oil and gasoline from automobiles and objectionable gas and cinders from the stacks of large heating and power plants. On dry, windy days, dust and dirt from building operations and from the streets add to the difficulty. The effect upon ventilation from contamination of the air by the human breath was discussed to considerable length, inorganic contamination, such as dust or gas in the air, was given passing mention and the heat given out by different kinds of lights was tabulated.

Air Quantities and Cubic Contents

In a school room used for a few hours in succession it is usual to allow 1800 cu.ft. of air per hour per pupil; for theaters used only once a day for a few hours, 1000 to 1500 cu.ft. per hour per occupant; for hospitals, 3000 to 4000 cu.ft. per hour per bed. Large banking rooms may have about three changes of air per hour; engine and boiler rooms, according to the machinery layouts, 10 to 40 changes of exhaust per hour and 8 to 25 changes of air supply per hour. These values must be used with discretion because special conditions may require a greater amount of air.

To obtain the amount of air advocated above there are in general two ways: the natural and the artificial. The only natural means that need be considered are the windows and it is but right to point out that perhaps 90 per cent. of all buildings are ventilated in this way. Drafts and uneven temperatures are the chief objections to natural ventilation and besides the possibility of securing an ample amount of air through windows has its limitations, depending, of course, on the cubic contents available per occupant and the number of windows. The cubic contents available for each person in a room is generally called the "air cube" and a fair average in different buildings is as follows:

Hospital wards (modern)	2000 cu.ft. per bed
School (by law)	200 to 240 cu.ft. per pupil
Sleeping rooms (ordinarily in suburbs)	500 cu.ft. per occupant
Liberal offices	500 cu.ft. per occupant
Crowded offices	250 cu.ft. per occupant
Theaters	200 to 400 cu.ft. per person
Ordinary railroad car	60 to 70 cu.ft. per person
Electric car (with strap hangers)	25 to 30 cu.ft. per person

With a skillful arrangement of windows and heating surfaces, with people allowed to move away with perfect freedom to places where an open window does not annoy them and with an air cube of 500 cu.ft., fair results with window ventilation may be secured, provided none of the objections general to window ventilation exist around the building. To secure a constant supply of air by manipulating the windows is almost impossible. There is generally too much, or too little air, and the economy in fuel usually attributed to this method of ventilation is but seldom secured.

Dust Troubles

The shortcomings of window ventilation for many kinds of buildings has been the cause of installing artificial ventilating plants which furnish a constant supply of tempered air irrespective of wind and weather conditions. The quality of air secured by artificial ventilation is at the present time a much discussed subject. If only exhaust ventilation is provided, the air then enters ordinarily through the windows to be heated, in the colder weather, to room temperature by the radiators. If air is supplied by a blower, it is heated to nearly room temperature by a tempering coil. There are people who seem to think that air heated by a tempering coil is impaired for breathing, evidently basing their judgment upon the dryness of the air and the burning of dust on radiators and pipes. The drying effect of heat cannot be avoided unless the air is moistened. As to the burning of dust on heated surfaces, it should be realized that different kinds of dust require higher or lower temperatures before burning can take place. The approximate temperature at which the ordinary dust begins to burn is 160 deg. F. Thus a steam radiator, whose temperature is generally about 212 deg. F., will be capable of burning this dust, whereas a hot-water radiator, at, say, 140 deg. F., would not affect the dust at all.

After heat has been turned on, scarcely any dust will settle on the hot radiators, because of the rising air current carrying away the heat. Almost any steam-heating plant will smell at the beginning of the season, particularly if the radiators have not been cleaned during the summer, but if steam radiators are wiped off every day with a wet cloth no offensive odors from burning dust will be present.

Three Ways to Create a Flow of Air

In a ventilating system there are three ways of creating a flow of air. The flow may be due to wind velocity as utilized in vent and smoke-flue caps, generally called ventilators; to temperature difference, as in vent flues, or to mechanical means, such as blowers and fans. With ventilators the amount of air handled depends mainly upon wind velocity, and with increasing wind, where naturally more air is coming into the building, due to the many window leaks, and when the least amount of artificial ventilation is necessary, they will naturally handle the most air.

In many buildings the need of ventilation is greatest in the summer months, and at this time the vent flues will handle the least amount of air, because this depends on the temperature differences between inside and outside. The only positive means of supplying the air is by means of a blower or fan, for with either the amount of air handled does not depend upon the velocity of the wind or temperature conditions primarily.

The features of an artificial ventilating system to which most consideration must be given are the air inlet, the tempering coil, the duct system, and the cleaning

devices. The fresh-air inlet must be located at a point where such air really exists. This may be at the ground level or on the roof, or perhaps at a certain height between. Common sense in each case will dictate the best location. The opening must be protected against rain by louvers or hoods, and with a screen to keep out birds and debris of various kinds.

In the arrangement of the duct system, every precaution should be taken to guard against contamination. The practice of installing all kinds of pipes, even sewer pipes, in fresh air ducts, must be condemned. Many ventilating plants have proved a failure from this very reason.

The tempering coils must be designed and operated so as to secure an even temperature of air. Air filters and air washers for cleaning the air must be designated as necessary evils, for it would certainly be desirable if equally clean air could be secured without their installation. Generally speaking, washers have the advantage of cleaning the air more thoroughly than filters. On the other hand, air washers are costly to install and operate, and when they are not in operation the air is not automatically cleaned as with a filter.

Operation of Ventilating System

Temperature changes within a room with a ventilating apparatus must be effected carefully. The room, the hall, the theater or the schoolroom should be prepared for the best atmospheric and temperature conditions before the people assemble. It is almost invariably better to err on too low a temperature than too high, because it takes but a few moments to heat up a room, without any of the occupants knowing anything about it, whereas it is more difficult to cool a room, even a degree or two, without making it evident.

Air filters must be kept clean and all the sprays in continuous operation. The water should be renewed often, and the dust exhausted from the air removed, as otherwise objectionable odors will soon develop. The temperature of the primary coils for an air washer is better set low if the apparatus serves offices, schools, theaters, etc., as otherwise too much moisture will be added to the air. The dust systems must be kept clean, and all moving parts of the fan as well. The tempering coil should be cleaned at least once a year.

For the proper operation of ventilating apparatus the engineer requires a few instruments, such as accurate thermometers, a hygrometer, and an anemometer. The ordinary dry- and wet-bulb hygrometer or the sling hygrometer is sufficiently accurate, and, if properly handled, the anemometer will give approximate results. Another instrument which may occasionally become of value to the chief engineer is the ordinary U-tube draft gage for determining the working pressures of the apparatus. Care must be exercised to distinguish between the velocity, static and dynamic pressures.

In Europe, particularly in Germany, the operation of ventilating apparatus is quite different from here. In this country we are accustomed to rely as much as possible upon the automatic regulation of temperatures, air supply, etc.; in Germany the operation is mainly done by hand. In large plants will be frequently found complicated boards, not unlike switchboards, upon which are mounted numerous instruments, such as electric long-distance thermometers and micromanometers, gages, operating devices for large dampers, etc., all for the purpose of enabling the engineer to control the entire ventilating apparatus and temperature conditions existing in the building from his switchboard in the cellar. He can determine the pressures and temperatures existing in three or four parts of the house, and is supposed to work his ventilating apparatus according to a certain tabulated formula.

No centralized service will ever be successful, unless the engineer has an intimate knowledge of the plant and its workings. Few operating engineers in this country would take the necessary pains to properly operate a centrally controlled plant. For the meantime the localized automatic control is therefore superior, although a combination of both systems may be the ultimate outcome.

CORRESPONDENCE

Check Valves Relieve Trouble

In one of the buildings to which the writer supplies heat, both the one-pipe and two-pipe systems are installed. Some of the radiators are connected to the one-pipe system and all of the coils are on the two-pipe system. The building has three stories and basement and is heated from a central power house, the supply and return pipes being in the basement. The one-pipe radiators are tied in with the returns of the coils on all three floors. A great deal of trouble was experienced in getting the cold air out of the coils before the steam would close the automatic air valves. Especially was this true in the six pipe coils heating two large rooms on the top floor. The coils would be warm at the supply end and return end, but the center and largest part of the surface would be stone cold. The supply main entered the building, which is about 80 ft. long, at one side of the basement near the end, being carried to the center and down to the other end. From each side risers were tapped for each floor, the top story being supplied from risers at the extreme ends of the supply main.

In operation, the steam to the one-pipe system, which, of course, had the pressure of the main supply, would back up into the returns from the coils, heating the air valves and closing them before the cold air was all out of the coils. Consequently, the coils remained cold.

By closing the return valves of the coils at night after they were drained, and then opening them in the morning after the coils were heated, the trouble was relieved. This, of course, necessitated some one walking to the top and all over the building twice a day. Finally, vertical check valves were put in on the return lines just above each supply pipe of the one-pipe system and there has been no further trouble. The steam pressure closes the check valve so the steam cannot reach the air valve by the way of the return, and the weight of the returns readily opens the check valve.

H. S. Sweetser.

Medford, Mass.

Mixing a handful of burnt lime with 120 grams of linseed oil, boiling down to the usual consistency of putty and allowing the plastic mass to spread out in a thin layer to dry in a place where it is not reached by the sun's rays, yields eventually a very hard putty. When required for use it is made plastic by holding over the funnel of a lamp; on cooling it regains its hardness.—"Penberthy Engineer."

EDITORIALS

Economy in the Boiler Room

The articles now appearing in the "Engineers' Study Course," dealing with combustion and analysis of coal, should be generally appreciated as one has only to step into the average boiler room to see evidences of the lack of knowledge on fuel economy. While making rapid strides in power-plant management and campaigning for more efficient engineers the boiler room has in a measure been left to take care of itself and in many cases labor entirely unfitted to the trust has been put in charge of the boilers.

A man may be a good fireman from the standpoint of safety, he may keep his surroundings clean and always have the steam up to the "top notch," but this does not always imply that he is getting the best results out of the fuel. Does he know the quality of the gas he is permitting to escape into the chimney? Has he any idea of the amount of excess air going into these gases, either through the fuel bed or the numerous cracks and crevices present in many boiler settings? Is he sure that the draft is the best for the fuel used and the thickness of the fuel bed? With the reliable instruments that are on the market at the present time it is within the power of every engineer to intelligently answer the above questions.

We do not mean to infer that the engineer or head fireman should be put to the expense of purchasing these instruments himself. It is our opinion that the majority of plant owners or managers are willing to purchase such devices if the engineer can show that he is familiar with the subject of combustion and fuel economy and can convince the management that by the constant use of such devices, a check can be kept on the average running conditions and money saved thereby. A talk on so much increase in the ratio of evaporation per pound of fuel may perhaps not be convincing or even interesting to the management; it must be told in dollars and cents. The possibility of saving five or ten per cent. in the fuel bills will always appeal.

Many may know that it is possible to make a ten per cent., or even greater, saving by keeping everlastingly at the combustion problem. We have in mind one boiler that consumed seven per cent. less fuel for the same capacity after stopping up the small cracks and crevices in the walls.

Too many boiler plants have not been provided with apparatus to properly measure the amount of water put into the boiler, the amount of fuel fed to the furnace and the pounds of steam the boiler is giving in return. No one would think of operating generators without ammeters to indicate the work that is being done. Trying to keep informed as to the load on the generator by feeling the heat given off would be considered ridiculous, but that is about as reasonable as the way many boilers are operated. They can go on day after day with overloads or they can "loaf on the job" and it is all taken as a matter of course.

It is more important to consider as an inseparable part of the boiler equipment such devices as will show the water evaporated, the coal burned, the steam given out and the furnace efficiency than to equip the prime movers with proper instruments. Economy here is all important, for the fuel lost in the boiler room can never be reclaimed.

Even if the boiler room is not equipped with the instruments and devices necessary to insure economy, it should not give the engineer or fireman license for inaction. He can become informed on the operation and necessities of such appliances, and be in a position to take charge of plants which include them in their equipment. The study of combustion and fuel economy is certainly worth all the time put into it and will bring big returns.

⁂

Learn How To Learn

Why is it that the practical man has so little use for the fresh college graduate? It is because in the eye of the practical man the college man knows nothing. What, then, did he gain by the time spent in school? Just this, he learned how to learn.

If this one lesson is learned by the practical man the college graduate has but slight advantage over him. The college man advances (provided he has push and ambition) because he knows how to teach himself what he ought to know and how to take advantage of knowledge thrust in his way. Thus equipped one has mastered the hardest part of any department of engineering.

Some readers have a habit of passing up phrases which they do not understand and then wonder why the rest of the article means nothing to them. Skipping phrases and words in this way is a harmful habit and induces mental laziness and discouragement.

One of the best ways to learn how to learn is to take each article, phrase and word and pick it apart as though it were an engine that has broken down and is being examined to locate the trouble. Those who read continually (when they have the time) find that understanding soon comes with less effort.

Some engineers and power-house men long ago decided that they have no brains for algebraic expressions, figures and the like. While they feel this way they will make no progress, but if they will only determine to apply themselves more, and make a business proposition of their studies, they will find it a kind of business that will pay good dividends in the future.

⁂

What Arbitration Can Do

That the wages of thirty-one thousand locomotive firemen can be increased three and a half to four million dollars a year without a strike which would have tied up fifty-four Eastern railroads, is a splendid testimony to arbitration as a means of settling capital and labor differences.

When this action of the firemen is contrasted with the stand taken by both sides in the majority of recent strikes,

it seems strange that the latter did not find some way to avoid paralyzing the big business interests and working great hardship to the workingman and seriously inconveniencing to the public.

It must be admitted that the patience and conservatism of the firemen were strong factors in the peaceful settlement of their contentions. Their vocation closely parallels that of the men in the stationary engineering field; both demand intelligence and skill and a knowledge that much depends upon their individual efforts. This is the main reason, we believe, why there have been few or no serious disagreements between power-plant employees and their employers.

Should the time come when it will be necessary to adjust questions of large moment in the operating engineering field, it is to be hoped that recourse will first be had to arbitration. While falling far short of being a panacea for all industrial difficulties, it furnishes the best means at hand for their peaceful settlement.

Much-Needed Information

Two difficulties usually confront an editor when gathering material for an article descriptive of a power plant. These are getting cost data and accounts of operating troubles.

Just why the designing engineer should be reluctant to give out cost figures is hard to conceive. Surely there are no trade secrets to be thus divulged, and if there were, the data need not be of such a detailed nature as to reveal discounts, etc. What is most needed, is data upon various types of plants dealing with the total cost, cost of buildings, main units, auxiliaries and electrical equipment per horsepower or kilowatt of capacity. Most books on power-plant design are sadly deficient in this respect.

By giving out such information, consulting engineers would profit in the long run. In return for a comparatively small amount of information each individual would receive a large amount relative to a great variety of plants. This would be especially advantageous to the smaller firms whose business is not extensive enough to enable them to compile data of their own dealing with different types of plants.

Operating troubles generally do not reflect upon the apparatus itself. Sometimes they are due to wrong application of perfectly reliable equipment while more often they are the result of unforeseen circumstances or local conditions. In either event experience is the only remedy and engineers should gladly give their fellows the benefit of such experience. In this way many mistakes would be averted and much labor and expense saved.

Not long ago manufacturers were wont to carefully guard their shops from all visitors and even engine builders did not care to give out the performance of their products. Since the organization of several of the large engineering societies, however, with their custom of presenting and discussing technical papers, this condition has changed and much useful information is disseminated throughout engineering circles. It is hoped that this habit will be extended to include more discussions of costs and operating troubles, for, without question, both are subjects which are of interest, at least, to very many, and of intimate concern to not a few.

Discouragement of Ingratitude

What can requite the engineer who takes a plant without enjoying the confidence of his employers, is thwarted in nearly every improvement he wishes to make, and criticized no matter how well he does? We heard of such a case only a few days ago. In spite of no coöperation and in the face of all evidences that his employers are not satisfied with him, he has cut down their coal consumption from 24 to 10½ tons a day on an average. (One day recently he burned only 9¼ tons.) Where before the plant had to shut down at least once a week for some cause or other, he has had no shutdowns since he was there. In fact, without having the chance to do half the things to improve the plant that he would like to do, he is already saving the company four times his salary and yet he does not know what moment he may be discharged.

What is hard work compared to ingratitude? We can do to the very limit of our ability and gladly while it is appreciated, but nothing can chill our enthusiasm quicker or more thoroughly than failure to recognize our efforts. There remains only one comfort—the inner satisfaction of having done our best—a conscience that cannot criticize.

The professional engineers are commencing to consider the advisability of legislation which will provide for their license or registration. A conference committee of the national engineering societies held a meeting during last month, to which were invited also representatives of the National Electric Light Association, the American Gas Institute and the Institute of Consulting Engineers, to consider the propriety of preparing a bill for registering engineers, which should be offered to the legislatures of New York and other states, should these bodies consider legislation in this matter essential. It was the sense of the conference that such a bill be prepared and this recommendation has been made to the councils of the organizations represented. The national engineering societies comprise the civil, mechanical, mining and electrical engineers. It will be but a step from the examination and registration of such men to the examination and licensing of operating engineers.

A correspondent of *Engineering* (London) suggests that the pitting and corrosion which are of such frequent occurrence in condenser tubes subjected to the action of sea water, may be due to the internal stresses set up in the drawing of the tubes. He cites a number of cases of corrosion in copper pipes, and other situations which appear to be due to some such cause, and has been successful in preventing corrosion where it had been occurring by annealing the pipes before they were put into place.

When a society only three years old can get out the crowd and the enthusiasm that was evidenced at the dinner of the American Institute of Boiler Inspectors (referred to on page 692) it is founded on right principles and made up of the right stuff. POWER is so heartily interested in decreasing accident and promoting safety in the handling of power-plant equipment that it is naturally in sympathy with the purposes of this society and wishes it continued and ever increasing success.

READERS WITH SOMETHING TO SAY

Why Belt Ran to One Side

Recently I erected a main-line shaft. Every care was taken to get the shaft in line and level, and when it was up I felt sure there would be no trouble encountered in starting. The next day I put on a 12-in. main-driving belt and started the engine, when, to my astonishment, the belt crawled over to one side of the pulley, about 4 in. of it sticking over the side. I was told that the shafting was out of line or out of level and it would be quite a job to change it, but I knew that was not the trouble for I had rechecked for line and levels after it was up. Another suggestion was that the belt was not laced to give even tension across it, and that the tight side was pulling away from the center, but as I had carefully squared the ends of the belt before lacing it and had drawn and laced the ends square with the aid of a belt clamp, I knew that could not be the cause of the trouble.

I again tested for levelness, thinking that possibly the sides of the building foundations might have settled unevenly, but found everything all right. I then tried the crown of the pulley on the main shaft to see if it was in the center of the pulley and found it all right. Next I started the engine to see if the pulleys ran true and found they did; they were also in line. For a few moments I could not imagine what else could be wrong. Finally I thought that possibly the pulley might be larger in diameter on one side than the other. After measuring both sides with a steel tape I found a difference in the measurements for both sides of the pulley of about one inch. Here, then, was the seat of the trouble.

The pulley had a wooden rim, solid cast-iron center, and to take it off the shaft would mean taking down the shaft, which would require at least a day's work. I set a temporary wooden rest in front of the pulley, took off the 12-in. belt and replaced it with a 3-in., which was positively guided to the small diameter end of the receiving pulley and then the large diameter end was turned down to equal the other end, using a common wood turner's chisel, the crown was also reduced a little as this change had increased the amount of crowning. The pulley was smoothed and the 12-in. belt put back. This time it ran true in the center and has never shown the least tendency to crawl to one side.

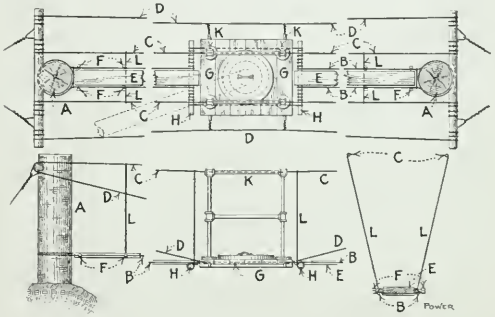
GEORGE P. PEARCE.

Exeter, N. H.

Miniature Suspension Bridge

At a certain New England plant, it became necessary to extend the injection pipe of the condenser 30 ft. into the river, where soundings revealed deeper and cooler water. There was danger that the foot valve, which was in the channel, would frequently become choked with fish and floating débris. Constructing a box for the protection of the valve was not difficult, but to design a passageway and platform over the water, that the screen might be daily cleared, demanded ingenuity.

The illustration shows the construction of a suspension bridge, which solved the problem. As shown, *AA* are two posts about 90 ft. apart, mounted one on each side of the river in line with the mouth of the injection valve. Connecting them are ½-in. woven wire ropes *BB*, *CC* and *DD*. The wires *BB* lead from near the base of the poles, and, through lag screws *FF*, support the 10-in. planks *EE* and the 50x60-in. platform *G*. *HH* are two 2-in. pipes serving to spread the wires *BB* for the better support of



DETAILS OF BRIDGE CONSTRUCTION

the platform, as shown in the plan. The wires *CC*, besides helping to support the platform by passing through the top pipe of the railing *K*, serve also as hand ropes, being placed about 30 in. apart.

The main purpose of the ropes *DD* is to prevent undue swinging of the bridge while the screen is being lifted through the 30-in. opening in the platform. *LL* are heavy single-strand wires which secure the planks to the ropes *CC*, as is best shown in the right-hand sketch. They serve to equalize the strain on the upper and lower wires. As the wires are all galvanized they should last many years.

R. O. RICHARDS.

Framingham, Mass.

Engineers and the Central Station

The New York Edison Co. has been directing its advertising in POWER recently at the engineer rather than the owner. Through suggestions that by recommending the Edison service to their employers they can "get away from the disagreeable details" improve their condition and "get in on the executive side of the job" the Edison Co. is trying to get engineers by their own recommendations to let the Edison service in—and themselves out.

The engineer is apt to have less work to do and to get more time for self-improvement when the Edison service comes in, but his pay is apt to stop at the same time with the work, and self-improvement does not buy shoes for the children.

Any city plant of such size that the salary of a competent engineer will not be disproportionate to the output.

and which has use for its exhaust steam can make light, heat and power cheaper than the central station can make and distribute it. Any owner of such a plant who allows himself to become involved in a long contract with the central station is losing money, and the engineer is losing money, too, for, notwithstanding all the talk about getting in on the executive side of the job, cases are not in evidence where the engineers are getting more money for pulling Edison switches than for intelligently administering a complete power plant.

The writer recalls one case in which Edison service was substituted for the private plant and the engineer was retained to run the heating plant. He advised his employers that it would be more economical to operate their own light and power plant which was already installed, and supply the entire service. The York Service Co., a subsidiary of the New York Edison Co., made a bid to operate the plant for a fixed annual charge and got it. The engineer had to get out.

In another case a plant of about 500 hp. was being sought after by the central station, although the operating engineer did his best to induce the owners to continue operation. They would not listen to his argument, however, and the Edison Co. have a contract, a short one I believe, to supply the electric current. The steam part of the plant has to be run for manufacturing purposes as well as heating in winter, but a cheaper man can do this. The engineer now has to look for another position.

These are both fine examples of graduating to the larger and more productive side of the job, but perhaps it is only those who advise the employer to scrap his plant and use Edison service that are thus qualified.

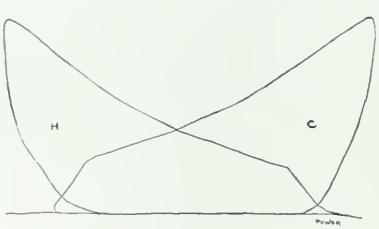
We hear much of the new buildings equipped with, and old plants shut down in favor of, Edison service. But we hear little of the new buildings in which plants are installed or those who resume plant operation after finding Edison service more expensive.

WILLIAM PECKHAM,
President, National Power Plant Assn.

New York City.

How Were the Diagrams Taken?

The diagrams herewith shown were taken from a 22x48-in. Allis-Chalmers, first-motion, Corliss valve, duplex hoisting engine, which is equipped with air brakes and reversing gear and drives two drums—one cage going up while the other goes down. It hoists up a



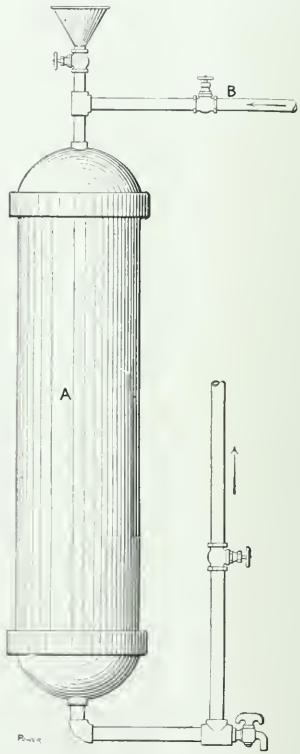
1500-ft. slope, one car every minute. The engines are new and in first-class condition. How were the diagrams taken?

W. H. BROOKS.

Franklin Furnace, N. J.

Another Boiler Graphite Feeder

To make this graphite feeder, I took an old cylinder (*A*) strong enough to stand a pressure of 150 lb. and connected it with a ¾-in. pipe (*B*) from the first section of our feed-water heater to the top of the cylinder; an air cock on the top of the cylinder is used to keep the tank from becoming air-bound. At the bottom of the cylinder is a ½-in. connection, with a cock, to draw off as much water as is required; also a 1-in. pipe, fitted with a valve, discharging from the bottom of the cylinder directly to the boiler-feed line. A funnel is provided to



GRAPHITE FEEDER USED WITH FEED-WATER HEATER

facilitate the pouring in of the mixed water and graphite.

The reason for taking water from the first section of the feed-water heater is that the water there is much cooler, which assists in giving the compound a rapid circulation through the cylinder and into the feed line, where the water is much hotter.

I find this way of putting the compound into the boilers in liquid form very satisfactory, the compound feeding through quickly when the water in the first section of the feed-water heater is cooler than that discharged from the compound cylinder into the feed line. If the water is of the same temperature, it will take longer to deliver the compound from the cylinder into the feed line.

LEWIS CARR.

New York City.

Trouble with Hot-Water Piping

In our ten-story office building we have a hot-water circulating system, the water being heated in a large iron tank in which there is arranged 36 ft. of 4-in. brass pipe. Through the brass pipe are circulated the vacuum returns. In the opposite end of the tank there are 36 ft. of 3-in. brass pipe in which the exhaust is circulated to help do the heating. The water is maintained at a temperature of 160 to 170 deg., and is kept under circulation continuously under a pressure of 90 lb.

Our principal trouble comes from the pipe lines giving out, and also the tank which has been renewed once. Renewing the tank is not so bad, but when it comes to the lines, which are in nearly every case buried in the floors, and in many cases in tile floors, it means a bad job. Is there any way in which we can safely clean these lines without taking up the piping? The pipes, of course, become well stopped up with barnacles and in some cases give out. The tank is cleaned regularly. We use city water which is from the Susquehanna River. It is filtered by the sand process and alum is added. Any information on the subject will be greatly appreciated.

ASA P. HYDE.

Binghamton, N. Y.

Diagrams from Poppet-Valve Engines

The accompanying diagrams taken from old-style poppet-valve engines may prove of interest to readers. Figs. 1, 2, 3 and 4 are from a very old-style engine, with double-seat poppet valves and was originally operated at 50 r.p.m.

It was installed in two or three different plants before reaching the plant at which these diagrams were taken, and, during the vicissitudes of its career, the governor after the valves had been ground in and as much of the lost motion in the valve-gear taken up as circumstances would permit.

Diagrams 5, 6 and 7 are also from an old-style engine built some time in the sixties. This engine had poppet-admission valves actuated through the governor and plain slide exhaust valves located beneath the cylinder and actuated by an eccentric on a shaft beneath the crosshead guides, and driven through a pair of double gears from the side or lay shaft.

Diagram 5 shows the valve setting as found and with the engine carrying a light load, while diagram 6 was taken under normal load. Diagrams 5 and 6 were taken with a 50-lb. spring, while diagram 7 was taken with a 30-lb. spring and shows the valve setting corrected.

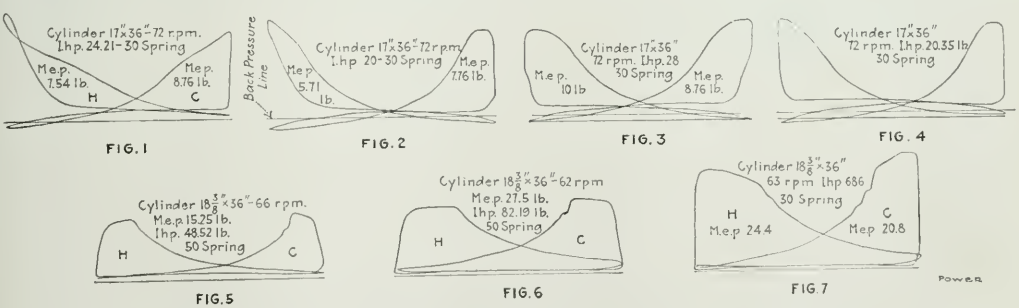
The governor and entire valve motion were in a deplorable condition, and, as the principal object of indicating was to determine the possibility of making this engine do an additional amount of work while an entire new plant was installed, no repairs whatever were attempted. With the steam pressure increased to 100 lb., this engine carried a load of 160 hp. for three months, when the new engines were installed.

CHARLES L. WARE.

Maynard, Mass.

Mud in Steam

Mud in boilers is common, but mud in steam lines is new to me. We have two 150-hp. return-tubular boilers operated together. Feed water is taken from a creek of apparently clear water, but we have considerable trouble with what appears to be mud in the steam lines. It is particularly troublesome on the pumps, coating the tappets and stopping the pump. I have taken a teaspoonful



DIAGRAMS FROM OLD POPPET-VALVE ENGINES, SHOWING EFFECT OF ADJUSTING VALVE-GEAR

had been adjusted so as to give a speed of 75 r.p.m. This was in excess of the power requirements of the last plant as is evidenced by an inspection of the diagram.

The port openings for both steam and exhaust valves are 2⅝ in. at the bottom and 2⅞ in. at the top, giving a port area of 11.9 sq.in. The result of this is plainly shown by the exhaust line, especially that part from the point of relief to mid-stroke. The back-pressure line has been drawn on each card and represents the actual pressure in the 6-in. exhaust pipe at about 3 ft. from the cylinder.

Diagram 1 shows the valve setting as it was originally found, while diagrams 2 and 3 show the successive steps in the setting of these valves, and diagram 4 was taken of sediment out of the tappet chest and inside of an hour taken out another.

The inside of the steam chests on all pumps and engines is coated with a similar substance. We scraped about a quart out of the steam chest in a 24x27¼-in. cylinder a couple of days ago, and only got about half of it out at that. It also affects the action of the governor on a high-speed lighting unit, because this mud gets in the steam chest and keeps the valve dry; oil seems to have very little effect on it.

I saw a ½-in. steam line filled after standing unused for two or three weeks, and the line had to be taken down and cleaned out before steam could get through it.

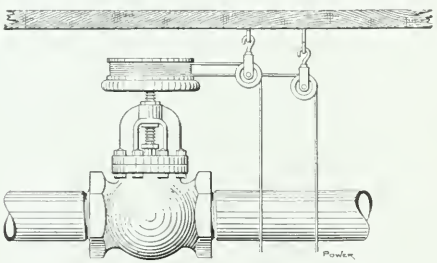
A duplex pump is located underground, and the exhaust steam was a source of annoyance, so we piped the exhaust into the suction, making the pump act as its own condenser, this solved the steam problem, and things went along nicely for about two days, when it was necessary to repack the plungers, upon taking off the follower, not a sign of the old packing was in evidence; the plungers were as bare as the day they were made, and that was the case for some time. The packing would disappear in two or three days.

We finally came to the conclusion that this was because the pump was not closely watched and because of a small sump. The pump would run out of water every once in a while and the steam entering the water cylinder would burn out the packing or soften it so that it would separate. We piped the exhaust to the atmosphere and have since had less packing to do.

White Horse, Y. T. H. TALBOT.

Manipulating Overhead Valve from Floor

A valve in our plant must be opened and closed many times a day. To do this, one must climb a ladder, as the valve is connected in a line that "hugs" the ceiling. To save myself the labor of climbing the ladder, I improved



OVERHEAD VALVE OPERATED FROM FLOOR BY CORD

the valve in the following manner:

From a large block of wood a flanged drum was made to be fastened to the handwheel of the valve. A ⅜-in. rope was wound around the drum and run through small pulleys, from which it dropped nearly to the floor. By simply pulling on the ropes the valve can be opened or closed from the engine-room floor.

Holly, N. Y. MARTIN MCGEERY.

Saved Engine Oil

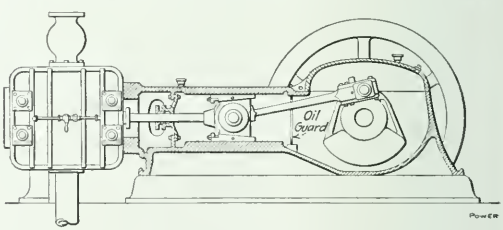
In a small plant the oil consumption of a four-valve, splash-oiled engine was extremely high. A pail was always kept under the oil stuffing-box to catch the drip and as all oil so secured was run through a filter it looked as if most of the oil was being saved. Quite a stream of oil came through this stuffing-box, which was difficult to pack satisfactory. Most packings contain rubber and such would soon be destroyed by the action of the oil. Packings containing no rubber were tried with but little better results, as the box was so shallow it was impossible to get in a sufficient amount to hold tight.

A new piston rod was put in and metallic packings were used, one for the steam and the other for the oil stuffing-box. The results were disappointing, as the oil came through almost as persistently as before, although the steam-rod packing worked satisfactorily and both sets were identical. No mechanical defects were apparent on the oil packing and after 30 days' running there was but a very slight improvement.

Various grades of oil were tried with but little difference in the result. It was then observed that when the engine was operating a light smoke continually issued from the two top ventilators of the engine frame. A finger rubbed on a window or hand rail in the engine room showed the presence of oil, and it was apparent that oil was vaporizing. As the engine was completely inclosed it was supposed that the oil got hot after a short run. At the close of a ten-hour run a thermometer was placed in the oil at the bottom of the engine frame, but it registered no more than 110 deg. F. Surely 110 deg. would not vaporize the oil. Cylinder oil was then tried and it was the same story over again.

Because so much oil worked past the oil packing it showed that considerable oil was thrown against this point by the rapidly moving parts dipping in the oil, and a good deal of this oil came in contact with the hot piston rod, hence vaporization. The problem then was to prevent the oil from getting back to this point.

In this engine the greater part of the oil is thrown by the engine crank and something like 90 per cent. would miss the crosshead and be thrown to the rear of the frame



SECTION OF ENGINE FRAME, SHOWING OIL GUARD

where the crosshead splashed it on the rod, when it would work out through the stuffing-box.

After various experiments a sheet-iron plate was placed across the frame close to the engine crank. It was tightly fitted to the sides of the frame and in the center just enough space was left to permit the connection rod to work freely. This formed a partition that prevented oil getting to the crosshead and other parts except what was thrown through the slot in the plate. After this change the fog ceased coming from the ventilators and only occasional drops from the stuffing-box; further, a very material drop in oil consumption was accomplished. For instance, in a 269-hour run, 45 gal. of oil were used before the change, or six hours per gallon of oil. After the change but 4 gal. were used for 143-hour run, or 35.7 hours per gal. of oil. This saving in the amount of oil well repays the effort expended.

The oil people let us have their expert engineer who spent a day with us and materially assisted in making this saving. The engine was watched carefully for the next few days for signs of insufficient lubrication, but it appeared to be getting all it required, and after 60 days' operation, no bad effects have been observed.

Geneva, Neb. G. S. SPRAGUE.

QUESTIONS BEFORE THE HOUSE

Wavy Lines on Pump Diagrams

In reply to S. F. Reynolds' query, in the Apr. 8 issue, as to what causes the wavy suction lines on his pump diagrams, I would suggest as follows:

In the first place this wavy line is due to the fact that the suction pressure is not constant at that part of the stroke which is shown from the diagram to be the beginning of the stroke. This is, no doubt, due to the sudden reversal or stoppage of the movement of the water column, which occurs in all reciprocating pumps at the end of each stroke. This sudden stoppage causes fluctuations in the suction pipe and vacuum chamber, which momentarily bring the suction pressure first up, then down, giving the wavy line as shown. These irregulatities may be decreased by using a vacuum chamber in the suction line of the pump, but can probably never be entirely eliminated. The writer has never seen a pump diagram in which the suction line was entirely free from "waves."

GRANDON D. GATES.

Seneca Falls, N. Y.

Thermometer and Mercury-Column Readings on High-Vacuum Condensers

In the Dec. 31 issue, page 984, is a letter from James L. Haynes, discussing an article on the above subject that appeared in the Nov. 19 issue. I wish to submit the following comment on Mr. Haynes' letter:

Since most of the air in the condenser seeps in through the pores of the condenser and the exhaust piping and their joints, particularly the latter, the percentage of air present in the steam at the exhaust nozzle of a steam turbine is negligible. If an accurate thermometer is placed either in the exhaust nozzle of a turbine or in the exhaust piping leading to the condenser and so inserted that it is subjected to the action of the flowing steam, not being placed where a pocket of air can form, it will give the temperature corresponding to the absolute exhaust pressure at that point more accurately than the average or ordinary mercury column. This will eliminate correcting for the barometric pressure, the difference of elevation between the barometer and the mercury column, using the correction constant of the barometer if an aneroid is used, and correcting for the temperature of the mercury and the scale used and for the capillarity of the glass tube, aside from any accidental errors.

However, the metal-case thermometer used must be accurate and placed near the turbine-exhaust nozzle and so designed that the mass of the metal case is small so as not to give too great a time lag to the thermometer registration. Also the metal case which screws into the piping wall should be insulated from the thermometer to prevent error, due to the heat flowing from the hotter walls of the turbine cylinder.

Incidentally a thermometer is more sensitive for high vacuum (see Table 1, in Marks & Davis "Steam Tables").

While with a reciprocating engine the exhaust steam may be superheated, due to the reëvaporation at a lower pressure of the steam initially condensed on the cylinder walls, with a turbine and its continuous flow of the steam, there is not much chance of getting any superheat in the exhaust steam, under any commercial conditions of operation.

Steam Pressure Lb Absolute	Gage	Initial	Superheat Deg F. Necessary to Get Superheat in the Exhaust Steam						
220	205.3	430	570						
200	185.3	410	550						
180	165.3	390	530						
160	145.3	370	500	650					
140	125.3	340	470	620					
120	105.3	....	430	580	650				
100	85.3		390	540	600	700			
80	65.3				480	570	630		
60	45.3				390	480	530	630	
40	25.3					420	470	560	700
30	15.3							380	630
15	0.3								460
Absolute exhaust pressure pounds./0" Vacuum inches		14.7.	8	4	3	2	1.5	1.0	0.75
bg.....		Atmos	4"	21¼"	23"	25"	26"	28"	29"

Note—These values were taken from the Mollier chart in the Marks & Davis book of steam tables.

The turbine-efficiency ratio on the Clausius (Rankine) cycle will run from 50 to 80 per cent., and the heat losses, due to bearing friction and to the residual velocity in the exhaust steam, do not affect the expansion of steam in the blading nor the quality of the exhaust steam, so that, for all practical purposes, we can consider the exhaust steam as not being superheated.

The accompanying table gives the necessary superheat in the steam for the exhaust steam to be superheated, assuming a barometric pressure of 14.7 lb. per sq.in. and adiabatic (perfect) expansion.

CHARLES K. CARPENTER.

Ithaca, N. Y.

Another Blowoff-Tank Explosion

In the Mar. 4 issue appears an account of a blowoff-tank explosion which is similar to an accident that happened here recently.

We have two boilers, the blowoff pipes of which enter a common blowoff tank placed just outside the boiler-room wall, with the top of the tank about 2 in. below the ground level. This tank is cast iron 3 ft. in diameter and 3 ft. deep with a 4-in. pipe to the city sewer and a 2½-in. vent pipe fastened to the wall outside and rising 2 ft. above the roof. The pipes from the boilers to the tank are 2½ in. in diameter.

One morning, on blowing down a boiler under 75 lb. pressure, I had opened the blowoff valve about three-quarters of the way when there was a loud explosion outside of the building. Shutting the valve I found that the tank cover had been blown off. This cover was about 1 ft. in diameter and fastened to the top of the tank with six ⅜-in. bolts. These bolts had, with one exception, pulled through the top of the tank by breaking off pieces of the

head from the bolt-hole circle to the inner rim. One bolt held and with it was a piece of cover 3 in. in diameter. The rest of the cover, which weighed 15 lb., I found on the other side of three railroad tracks 160 ft. from the boiler room.

The real cause of the explosion has never been explained to me. It was a cold morning and ice might have formed in the pipe to the sewer or the pipe might have been obstructed in some other way, but it was unobstructed on the evening before, as was the 2½-in. vent to the atmosphere.

Perhaps some reader of POWER could give an explanation as to the cause of this accident.

L. H. STARK.

Delevan, Wis.

Use of Fuel Oil

Your editorial in the Jan. 14 issue, on "Use of Fuel Oil" appeals to me, as this question has been prominently before the engineers of this part of the country for several years.

Fuel is high priced at this point, there being no wood, and the poorest kind of slack costs $3 laid in the bin. Therefore, most steam plants in this vicinity are burning oil and engineers in this locality have done a great deal of experimenting as regards furnace design and arrangement. As for choice of burners, there have been only three different designs procurable. We have read everything available on the subject, which was very little.

Of course, the manufacturer of each burner gives his own product a flattering recommendation. Therefore I have a suggestion to make, which, if followed, should be of benefit not only to the oil dealers, but to the engineers who are using, or who may be contemplating the use of oil as a fuel. My plan would be, not for the manufacturers of the burners to get out a lot of literature on the subject, as they would be naturally prejudiced in favor of their own burners, but for the oil dealers' association to carry out the suggestions of your editorial by having a large number of blank forms printed, and distributed among engineers of power plants where oil is used for fuel, the printed forms to have a space for descriptions of the furnace design employed in each test made, and having the essential headings, such as temperature of oils, pressure of oils, pressure of steam used on the burner, position of dampers, ash doors, water evaporated per gallon of oil, and all practical details, though not going into such technical points as flue-gas analysis, etc., as very few engine rooms are equipped with instruments for obtaining such information, and reference to unnecessary refinement might discourage users of fuel oil from making returns of valuable practical data.

These blank forms should then be distributed among the oil-burning engineers in all sections of the country. The kind of burner used, and all other leading practical details regarding the oil system used should be included in the report forms. When these reports were returned to the associations, they could be summarized in the form of a circular for the mutual benefit of the oil dealers and their customers and sent out to users and prospective users of fuel oil. In doing this the association would not be showing partiality to any make of burner, and each engineer could see just what others were doing and how it was being done, and the movement would be bound to procure hundreds of new customers for the oil dealers.

Those already equipped with burners could remedy their faults and those contemplating the use of oil as a fuel could have the benefit of the experience of all the rest as a guide to their own choice of burner, and to their preferences in furnace designs.

If the association would not set this plan on foot, I believe it would be very helpful to engineers were the different engineers over the country to send such reports to POWER, and thus enable all interested to secure very comprehensive data on the subject.

JOHN PIERCE.

Kiowa, Kan.

[Our correspondent has offered some very sensible recommendations for putting the suggestions of our editorial into practical operation and it is to be hoped that the dealers in fuel oil will avail themselves of the opportunities referred to. Whether or not any action is taken by the dealers we will be glad to give space in the columns of POWER to any data that may be of value to those of our readers who are interested in the subject of fuel oil.—EDITOR.]

Blowoff Cock Explodes

The account of a piston explosion as described on page 321 of the Mar. 4 issue reminded me of a similar accident in our plant.

A blowoff pipe had split and the pipe fitter found it necessary to heat the blowoff cock to get it off after the pipe and cock had been removed from the boiler. The plug of the cock must have contained water, because soon after being placed in the forge, an explosion occurred, destroying the blowoff cock and doing considerable damage to the shop. Fortunately, no one was seriously injured.

B. S. HANSON.

Broad Brook, Conn.

Flow of Water over Weirs

B. D. Moses has made some serious errors in his article on the above subject, on page 258 of the Feb. 25 issue. In his treatment of the triangular weir he states that the discharge may be represented by a volume the value of which is

$$\tfrac{8}{15} K \sqrt{2gh}$$

where K is the ratio $b/2h$. He then states that if $K = 1$, then

$$Q = \tfrac{8}{15} \sqrt{2gh^5}$$

which is not consistent with the first equation.

[The placing of h^5 under the radical sign in the above formula, as given in Mr. Moses' article, was not the author's error, but was a typographical one.—EDITOR.]

Then introducing a coefficient of discharge of 0.6 he obtains

$$Q = 2.56\, h^2$$

which is not consistent with either of the above equations. None of the three are correct.

The volume in question has the value

$$\tfrac{8}{15} K \sqrt{2g}\, h^2$$

and, if $K = 1$ for the 90-deg. notch, then

$$Q = \tfrac{8}{15} h^{\frac{5}{2}} \sqrt{2g}$$

introducing the coefficient of discharge of 0.6 then

$$Q = 2.56 h^{\frac{5}{2}}$$

The value of the coefficient used is probably close enough for most purposes, but the more common value is

$$Q = 2.54 h^{\frac{5}{2}}$$

For a discussion of that point see POWER, Sept. 20, 1910, page 1684.

At the end of the article Mr. Moses states that the Francis formula for suppressed weirs is

$$Q = Cbh$$

in which C is a coefficient depending upon the number of contractions. In the first place a suppressed weir is one that has no contractions. The Francis formula for the suppressed weir is

$$Q = 3.33\ bh^{\frac{3}{2}}$$

The Francis formula for the weir with end contractions is,

$$Q = 3.33\ (b - 0.1\ nh)\ h^{\frac{3}{2}}$$

in which n is the number of contractions, usually two, though occasionally one may be encountered.

R. L. DAUGHERTY.

Ithaca, N. Y.

Should the Engineer Be Factory Fire Chief?

The editorial on the above subject in the Dec. 21 issue takes the correct position; but it might have treated the subject at greater length. Preventing loss by fire is so important in factories that it is worth discussing to some extent. The latest figures show that fire losses in the United States during 1912 reached 220 to 250 million dollars. Although this does not cover the losses of all fires, nevertheless, it is sufficient to stimulate anyone to action, especially if he is connected with manufacturing establishments, where the loss in any one case is generally very large.

The extent of the loss of human life has not been pointed out here; but the safeguarding of life should be the chief reason for fire prevention. From the way in which even ordinary precautions are sometimes ignored or violated, is it surprising that many factory owners have been put on trial for criminal negligence after a fatal fire in their establishments? If the risk of destruction by fire were to be reduced or the possibilities for the spreading of a fire reduced to a minimum, the rate of insurance would be lowered; the employees would, probably, work at a higher efficiency because the fear of a panic would be remote.

When a fire breaks out, the engineer is likely to be in the power house, which may be some three hundred feet from the main building. What is needed is not so much a single man who will act as fire chief, but a number of men well distributed about the plant, who will always be present to take immediate command of the workers in case of fire.

Whenever a fire alarm is given, it should be sounded in all parts of the property where the engineer might be, so that he could hurry to his post in the station and direct his men in their part of the fire fighting, which should be confined to the management of the fire pump, etc.

The engineer should also test all fire pumps at regular intervals to insure perfect readiness and prompt response in time of need, as well as inspect or suggest fire appliances about the plant.

ALBERT H. ISRAEL.

New York City.

[It was not our purpose to summarize editorially the means for fire prevention, as that is out of our field. Our aim was and is to stop the practice of adding to the responsibilities of the engineer by appointing him to assume the responsibilities of the factory fire chief.—EDITOR.]

Discussion of Oil-Flow Problem

In reply to the letter of H. O. McCarthy, in the Apr. 8 issue, as to why the new arrangement of piping causes the storage tank to fill with oil more quickly, I offer the following two suggestions:

With the new arrangement there is no direct connection between the tank wagon and the storage tank, while in the first case the oil was piped directly from the wagon. Possibly in the first case sufficient air did not reach the tank wagon to replace the oil flowing out, thus reducing the pressure on the oil in the wagon sufficiently to greatly retard the flow of the oil. When the open connection was made, air was more easily let into the wagon, thus increasing the flow. The increased size of the pipe in the new installation would not account, of itself, for the increased flow.

It is also possible that with the old arrangement of the closed circuit some entrained air was in the storage tank when the connection was first made. As the oil flowed in from the wagon this air was compressed and its pressure tended to retard the flow. With the open connection of the new arrangement the air escaped into the atmosphere, and all liquid surfaces were subjected to atmospheric pressure.

GRANDON D. GATES.

Seneca Falls, N. Y.

Engine Ratings

Probably many readers of POWER, like myself, would like to have others shed some light on the question of rating steam engines.

(1) If we take a modern high-speed engine, say 10x10, rated at 65 i.hp., making 350 r.p.m., taking steam at 100 lb. boiler pressure and cutting off at ¼ stroke, then with all conditions the same, except that the engine is loaded, requiring cutoff at ½ stroke, will it develop the increased power and give steady duty without undue heating of the bearings?

(2) Can continuous duty be obtained from this same engine developing 65 i.hp. running 250 r.p.m. supplied with steam at 100 lb. boiler pressure and cutting off at about ½ stroke?

(3) Or when developing 70 i.hp. running 375 r.p.m. and cutting off at about ½ stroke?

Assuming that the engine has proper proportions so that the different conditions of running will not affect the strength of the materials, the adaptability of the engine to the conditions proposed would seem to resolve

itself to the question of heating of the bearings. It should be noted that in condition (1) we would increase the power by continuing the initial pressure for a longer period of the stroke; in (2) we have maintained the nominal power by increasing the cutoff and decreasing the revolutions per minute, while in (3) we have increased the indicated horsepower by increasing the revolutions per minute.

The remaining question is: What provision do engine builders make for the varying conditions? Do they adhere to standards and furnish an engine that falls within those standards or do they proportion parts only for the conditions most favorable to the bearings?

Doubtless readers of POWER who are users of high-speed engines will be mutually benefited by an interchange of experiences in running such engines at speeds and loads different from the cataloged ratings.

ROBERT GILSON.

Buffalo, N. Y.

How Exhaust Valves Got Inverted

In reply to F. A. Hunter's inquiry as to how the exhaust valves got turned upside down as asked in the Mar. 25 issue, I would advise that there are only two ways that it could happen if the lines on the valves and cylinder coincide as they should.

One way is for the line to extend clear across the valve, but this is hardly probable as I never saw or heard of such a manner of marking a valve. The other way is for marks on the valves to be at 90 deg. to a center line drawn perpendicularly through the valve when the wrist-plate is on the center. The valves under discussion were marked on the side nearest the exhaust-pipe connection, as shown in Mr. Hunter's illustration. If both valves were removed at the same time it would be easy to get them mixed and, when putting them back, to put valve *A* in valve *B's* place when the valve would have to be upside down for the lines to match.

GEORGE P. BRANN.

Grinnell, Iowa.

Shall We Let the Foot-Pound Wabble?

C. P. Poole, in the issue of Mar. 18, mentions the question "whether it is more expedient in scientific work to take 746 as the exact equivalent (of the horsepower in watts) and let the foot-pound values wabble, or *vice versa.*" There is no need of having either the horsepower or the foot-pound wabble if we define the horsepower as 550 foot-pounds per second and as equivalent to 745.70 watts, which is the correct value to the fifth significant figure, if we define the pound force as the force which will give one pound of matter an acceleration of 980.665 cm. (=32.1740 ft.) per second, this acceleration being that produced by gravity at latitude 45 deg. at the sea level. With this value 1 kw. = 1.3410 hp., correct to the fifth significant figure.

He says also "the common pound and ounce weights have not the same absolute values at all latitudes." This is true only if he means by pound weight not a certain piece of metal but the attraction of gravity on that piece of metal. The piece of metal has the same value, that is, quantity of matter at all latitudes, and the quantity is determined by weighing it on an even balance scale against a standard piece of metal, known as the standard pound, at any latitude whatever.

I agree with him that 746 watts and 550 ft.-lb. per sec. will always be used as horsepower equivalents in ordinary everyday work, just as 1.34 hp. will be used as the equivalent of a kilowatt, but for accurate scientific work the figures that should be used are 745.7, 550 and 1.341.

Mr. Poole once criticized the table of equivalent values given on page 1347 of my pocketbook, tenth edition, as being in some respects inaccurate. I have had a new plate made with the figures corrected, and inclose a proof. You will see that in it I make 1 hp. equal 745.7 watts. I shall be glad if you will reprint this table.

New York City. WILLIAM KENT.

[We appreciate the privilege of reprinting this table as we know it will be useful to many of our readers. Any who have the older edition of Professor Kent's "Mechanical Engineers' Pocket Book" will do well to preserve this table in it.—EDITOR.]

EQUIVALENT VALUES OF ELECTRICAL, MECHANICAL AND HEAT UNITS

Unit	Equivalent Value in Other Units
1 Kw.-Hour =	1,000 watt-hours 1 341 horsepower-hours 2,655,220 ft.-lb. 3,600,000 joules 3415 heat-units 367,100 kilogram-meters 0.234 lb. carbon oxidized with perfect efficiency 3 52 lbs. water evaporated from and at 212° F 22 77 lbs. of water raised from 62° to 212° F
1 Hp.-Hour =	0 745 7 Kw.-hour 1,980,000 ft.-lb. 2546.5 heat-units 273,740 kg.-m. 0 174 lb. carbon oxidized with perfect efficiency 2 62 lb. water evaporated from and at 212° F 17 0 lb. water raised from 62° F. to 212° F
1 Kilowatt =	1,000 watts 1 3410 horsepower 2,655,220 ft.-lb. per hour 44,254 ft.-lb. per minute 737.56 ft.-lb. per second 3415 heat-units per hour 56.92 heat-units per minute 0.9486 heat-units per second 0 234 lb carbon oxidized per hour 3 52 lb. water evaporated per hour from and at 212°

Unit	Equivalent Value in Other Units
1 Hp. =	745 7 watts 0.7457 Kw. 33,000 ft.-lbs. per minute 550 ft.-lbs. per second 2,546.5 heat-units per hour 42.44 heat-units per minute 0.707 heat-units per second 0.174 lb. carbon oxidized per hour 2.62 lbs. water evaporated per hour from and at 212° F
1 Joule =	1 watt second 0.000000278 Kw.-hour 0.102 kg.-m. 0.0009486 heat-units 0.73756 ft -lb
1 Ft.-lb. =	1.3558 joules 0.13826 kg.-m. 0.0000003766 kw -hour 0.0012861 heat-unit 0 0000005 hp.-hour
1 Watt =	1 joule per second 0 001341 hp. 3 415 heat-units per hour 0 73756 ft.-lb. per second 0 0035 lb. water evaporated per hour 44 254 ft.-lb. per minute
1 Watt per sq. in. =	8 20 heat-units per sq.ft. per minute 6373 ft.-lb. per sq.ft. per minute 0.1931 hp. per sq ft.

Unit	Equivalent Value in Other Units
1 Heat-unit =	1054.2 watt-seconds 777.54 ft.-lb. 107.5 kilogram-meters 0.0002928 kw.-hour 0 0003927 hp.-hour 0.000685 lb. carbon oxidized 0 001030 lb. water evaporated from and at 212° F
1 Heat-unit per Sq. Ft. per min. =	0.1220 watt per sq.in. 0 01757 kw. per sq.ft. 0.02356 hp per sq.ft.
1-Kilogram Meter =	7.233 ft.-lb. 0.000003653 hp.-hour 0 000002724 kw.-hour 0.009302 heat-unit
1 lb. Carbon Oxidized with perfect Efficiency =	14,600 heat-units 1 11 lb. anthracite coal oxidized 2.5 lb. dry wood oxidized 22 cu.ft. illuminating gas 4 275 kw.-hours 5.733 hp.-hours 11,352,000 ft.-lb. 15 05 lb. of water evaporated from and at 212° F
1 lb. Water Evap. from and at 212° F =	0 2841 kw.-hour 0 3811 hp.-hour 970.4 heat-units 104,320 kilogram meters 1,023,000 joules 754,525 ft.-lb. 0.066466 lb. carbon oxidized

INQUIRIES OF GENERAL INTEREST

Fitting Piston Rings—When new piston rings are in position how far apart should the ends be?

A. P.

About $\frac{5}{64}$ in. for a cylinder of average size.

Pump Slip—What allowance is usually made for slip in pumps?

E. S.

For new pumps working at normal speed 5 per cent. is usually allowed for slip.

Bypass Valve—What is a bypass valve and what is it for?

J. P.

A bypass valve is a gate or disk valve (usually) with a bypass or outside connection, containing a small stop valve, between the spaces on the sides of the disk. The bypass valve is for use in large mains as a stop valve against considerable pressure. The bypass makes it easier to open or close the main gate because it equalizes the pressure on the two sides of the gate.

Testing for Piston Leaks—How should a steam-engine piston be tested for leaking?

I. W. T.

One head should be taken off and steam admitted to the other side with the piston at each end of the stroke and also with the piston blocked at mid-stroke and preferably several intermediate positions. This will detect unequal wear, as at the center of the cylinder or over any soft spots in the cylinder metal.

Altitude and Boiling Point—Is it true that the boiling point of water (212 deg. F.) declines one degree for each 1250 ft. of elevation above sea level?

E. S.

As each 1000 ft. of elevation results in a reduction in atmospheric pressure of very closely ½ lb., then, by interpolating values given in Marks and Davis steam tables, it may be found that at the first 1250-ft. elevation water would boil at 209.82 deg. F., and for the second 1250 ft., i.e., at 2500 ft. above sea level, at 206.95 deg. F., so that the reduction of the boiling point is not 1 deg. per 250 ft., nor does it vary directly in proportion to the elevation above sea level.

Feed Through Blowoff—In a certain plant the boiler has a combination blowoff and feed pipe. The engineer claims that he has had no trouble with the arrangement and that he is able to keep his blowoff pipe clean. Is it good practice to feed a boiler in this way?

S. R. B.

Feeding through the blowoff to keep the latter open is very old. It is objectionable where the constant discharge tends to wear out the blowoff connections due to the scouring action of gritty feed water, for it may bring about the disabling of the feed connection at a place where it is not readily detected.

Tank Diameter—What will be the diameter of a cylindrical tank 68 in. high, having a capacity of 50 liters?

H. V. W.

One liter is equal to one cubic decimeter, which is equal to 61.023 cu.in. Therefore, the tank contains

$$50 \times 61.023 = 3051.15 \text{ cu.in.}$$

Being 68 in. high, the cross-sectional area will be

$$\frac{3051.15}{68} = 44.86 \text{ sq.in.}$$

The area of a circle equals $0.7854\ D^2$, where D = diameter. Then

$$\sqrt{\frac{44.86}{0.7854}} = 7.55 \text{ in.}$$

is the required diameter of the tank or about 7⅝ in.

Saving Heating Coil Returns—We have heating coils supplied with exhaust steam at 3 to 5 lb. pressure. No attempt is made to save the returns. The engine uses about a pint of cylinder oil in a 9-hr. day. Would it be advisable to return the condensation from the coils directly to the boilers?

J. V. N. C.

While most of the oil can be taken out of the steam by inserting an oil separator in the supply pipe to the coils, the remaining oil may be sufficient to do damage to the boilers. The proportion of oil that may be present without injury to a boiler is variable, seeming to depend on the analysis of the feed water. If used over and over, a considerable quantity of oil may be deposited, and if not thoroughly washed out, may cause the boiler sheet to be burned. By collecting the condensation first in a hotwell, much of the oil may be separated from the water fed to the boiler by putting the suction-pipe inlet well below the surface of the water.

Selecting Boiler for Given Engine—How is it known what size boiler will be necessary to supply an engine of a certain horsepower?

J. P.

In ordinary good forms of boilers 10 sq.ft. of heating surface will develop one horsepower with ordinarily good fuel, firing and draft. A boiler horsepower corresponds to an evaporation (equivalent) of 34½ lb. of water per hour. This is usually 30 lb. at the actual boiler pressure carried. The steam consumption of the engine under consideration is assumed to be known as so many pounds per horsepower-hour. This multiplied by the engine horsepower will give the pounds of steam required per hour. The latter divided by 30 will give the required boiler horsepower and the last named, multiplied by 10, will give the heating surface necessary. Boilers can be forced above their rated capacity easily so that overloads on the engine can be handled in that way, but it is common to provide a little excess boiler capacity so that forcing will not be called for.

Sizes of Plant Parts—We now have a 315-hp. motor load and want to add about 90 hp. in about a year. The motors are three-phase, 60-cycle, 440-volt. What size boiler, engine and generator are required?

C. M. M.

The total motor load will be

$$315 + 90 = 405 \text{ hp.}$$

which is equivalent to

$$\frac{405 \times 746}{1000} = 302 \text{ kw.}$$

Assuming an average motor efficiency of 88 per cent.

$$\frac{302}{0.88} = 344 \text{ kw.}$$

is the input to the motors.

Allowing 4 per cent. for distribution and line losses

$$\frac{344}{0.96} = 358 \text{ kw.}$$

is the required generator output.

A generator of this size would have an efficiency of about 92 per cent. Therefore,

$$\frac{358}{0.92} = 390 \text{ kw.}$$

must be put into the generator. This would correspond to a brake horsepower of

$$\frac{390 \times 1000}{746} = 522 \text{ hp.}$$

Say a 525-hp. engine would be required.

A compound engine of this size operated condensing would take about 18 lb. of steam per horsepower-hour

$$525 \times 18 = 9450 \text{ lb. of steam per hr.}$$

A boiler horsepower being about 30 lb. of steam per hr. the boiler horsepower required would be

$$\frac{9450}{30} = 315 \text{ b.hp.}$$

It would be preferable to have the boiler plant in two or three units, so as to always have one spare. Boilers can be run at 50 to 100 per cent. overload continuously when necessary, so that two 175-hp. boilers or three 125-hp. would be about right.

The above has assumed the motor load to be the maximum actual, not the sum of the normal ratings of the motors installed. If the latter was meant and only a certain per cent. of the total capacity is used at any one time all of the figures about given should be correspondingly reduced.

ENGINEERS' STUDY COURSE

Principles of Combustion—IV

Weight of Air Required

So far we have been talking about and figuring for the quantity of oxygen required for the combustion of the various elements.

The only cheap source of oxygen for the purpose of combustion is the air, which is free for everyone to use. The nitrogen of the air is an incombustible gas; that is, it will not burn with oxygen no matter how much it is heated, neither will it burn with any of the combustibles of the fuels. Hence, it is entirely useless for the purpose of combustion. But, there is no economical way of separating the oxygen from the nitrogen and as they are thoroughly mixed together we must supply the nitrogen to the fire along with the oxygen.

As the ratio by weight of nitrogen to oxygen is 76.85 to 23.15, for every pound of oxygen required we must supply

$$\frac{76.85}{23.15} = 3.32 \text{ lb.}$$

of nitrogen and hence for every pound of oxygen required we must supply

$$\text{Oxygen} + \text{Nitrogen} = \text{Air}$$
$$1 + 3.32 = 4.32 \text{ lb. of air}$$

Col. 8, Table I, gives the pounds of air required per pound of combustible in Col. 4. These figures may be used to shorten the work when figuring the air required.

If, instead of burning just a single combustible element, such as carbon or hydrogen, we burn a fuel containing both of these elements, we figure the oxygen or the air required for the amount of each element contained in one pound of the fuel just the same as though that element was the only one under consideration. The sum of the amounts of air required for each element then equals the amount of air required per pound of the fuel in question.

Thus, if we had a coal which contained, say 80 per cent. carbon; 5 per cent. available hydrogen; 2 per cent. sulphur; 1 per cent. nitrogen, and 7 per cent. ash; the air required would be estimated as follows:

Carbon contained in a pound of the coal equals 0.8 lb. From Table I, Col. 8, air required for complete combustion of one pound of carbon equals 11.52 lb. Then the air required for 0.8 lb. carbon equals

$$0.8 \times 11.52 = 9.216 \text{ lb.}$$

The available hydrogen equals 0.05 lb. Air required per pound of hydrogen (Table I) equals 34.56. Air required for 0.05 lb. hydrogen equals

$$0.05 \times 34.56 = 1.728 \text{ lb.}$$

Adding these two quantities together, we have

Air required for carbon in coal	9 216 lb.
Air required for available hydrogen	1 728 lb.
Air required per pound of coal	10 944 lb.

The air required for the sulphur in the coal we neglect as the amount of sulphur is small and, besides, the sulphur may already be combined with some other element and hence be incombustible anyhow. The ash and nitrogen, being incombustible, require no air.

A couple more illustrations of how the weight of air required for a given weight of fuel is estimated may assist to fix the method in mind more securely. Let us assume that we are burning a fuel oil in our plant which is composed of the following: Carbon, 82 per cent.; available hydrogen, 13 per cent.; moisture, 5 per cent. How many pounds of air are theoretically required for the combustion of this oil?

In every pound of the oil there is 0.82 lb. of carbon. Then, as one pound of carbon requires 11.52 lb. of air for complete combustion (see Table I, Col. 8) 0.82 lb. will require

$$0.82 \times 11.52 = 9.45 \text{ lb.}$$

Then 13 per cent. of a pound (the amount of hydrogen contained in 1 lb. of the oil) equals 0.13 lb. Referring again to Table I, Col. 8, one pound of hydrogen requires 34.56 lb. of air and hence 0.13 lb. requires

$$0.13 \times 34.56 = 4.49 \text{ lb.}$$

Adding the two quantities of air required, we have

Air required by carbon part of one pound of oil	9 45 lb.
Air required by hydrogen part of one pound of oil	4 49 lb.
Total air required per pound of oil	13 94 lb.

If we were burning a gas containing 70 per cent. carbon and 24 per cent. hydrogen, what would be the weight of air required per pound of gas?

Air required by the carbon in one pound of gas = 0.7 x 11 52 =	8 06 lb.
Air required by hydrogen in one pound of gas	8 29 lb.
Total air required per pound of gas	16 35 lb.

This same method of calculating the amount of air required by a fuel can be expressed in the form of a formula thus:

$$W = 11.52\ C + 34.56\left(H - \frac{O}{8}\right)$$

in which

W = Weight of air required per lb. of fuel;
C = Weight of carbon per lb. of fuel;
$\left(H - \frac{O}{8}\right)$ = Available hydrogen per lb. of fuel.

The available hydrogen is found by subtracting $\frac{1}{8}$ of the weight of oxygen in the fuel from the total weight of hydrogen in the fuel—just as the expression in the formula indicates.

Suppose we had a fuel with this analysis: Carbon, 78 per cent.; total hydrogen, 7 per cent.; sulphur, 1.5 per cent.; oxygen, 4 per cent.; nitrogen, 1.5 per cent., and ash, 8 per cent. Substituting in the formula we have

$$W = 11.52 \times 0.78 + 34.56\left(0.07 - \frac{0.04}{8}\right)$$

or

$$W = 11.52 \times 0.78 + 34.56 \times 0.065 = 11.23 \text{ lb.}$$

of air required per pound of fuel.

For those who wish to test their understanding of what has been set forth in the foregoing article and who wish practice in calculations involving percentages and decimal fractions, the following problems are offered:

Given a coal with the following analysis: Carbon, 78.75 per cent.; total hydrogen, 5 per cent.; oxygen, 2 per cent.; nitrogen, 2 per cent.; sulphur, 3.75 per cent.; ash, 8.5 per cent. Neglecting the sulphur, what is the weight of air required for complete combustion per pound of this coal? What would be the weight of the products of combustion?

Given a fuel oil containing: Carbon, 84.85 per cent.; available hydrogen, 11.15 per cent., and moisture, 4 per cent. What is the weight of air required per pound of oil and what would be the weight of the products of combustion?

A feed-water heater is handling 7575 lb. of water per hour. It raises the temperature of the water from 73 to 197.5 deg. F. How much heat is being put into the water per hour?

These problems will be fully worked out in the next article of this series which will appear next week.

Power Generation and Transmission in Industrial Works

In a paper on "The Layout, Design and Equipment of Industrial Works," read before the Liverpool Engineering Society, Andrew Home-Morton had the following to say concerning power generation and transmission:

Where the plant is compact and conveniently arranged within a radius, of, say, 100 or 150 ft., from the central power plant, mechanical transmission is most economical, while, with an increased radius, gas or electrical transmission has advantages, the former being the most enticing system from the point of view of thermal efficiency, but meantime having a more limited application.

Where tools are set widely apart, electrical transmission with individual motors is economical, although where it is possible to have a group of tools in a works, an independent gas engine or electric motor driving these through gearing is more economical than individual motors. Where the amount of power required for individual machines is small, it is almost always advisable to group them.

The question of reliability and consequent need for standby plant is also important. Practically any one of the systems, if properly installed, can be regarded as reliable, but the subdivision secured by the use of motors or small gas engines has advantages. The chief advantages of the electrical transmission system are its adaptability and the ease with which it can be extended, and its chief drawback is its cost, a part of which, at least, is due to the refinements which have been introduced into electrical controlling and operating mechanism.

Like the question of transmission, power generation depends for its solution upon the conditions of service. Where the power demand is intermittent, purchased electrical energy has advantages over all other systems, although for dock pumping, slipway haulage and other heavy intermittent loads, gas engines, using town gas, give economical service. For a moderately steady demand up to about 100 to 150 b.hp., the suction-gas engine has no rival. Above this load, it is possible to purchase a steam plant using highly superheated steam, which can generate 1 hp. per hour, at a fuel cost of a little over 1 lb., and a steam cost of approximately 8½ lb. Such a plant is, however, uncommon, and until it becomes more general, the range of usefulness of the suction-gas engine may be said to rise to 150 to 200 b.hp. Above this limit a steam plant using a low-grade fuel has advantages which have been greatly enhanced by the recent advance in the price of anthracite. The position of the steam engine or turbine for single-unit plants of over 200 b.hp. is not even today seriously assailed, except where the main question is complicated by side issues, or where the cost of coal is well above the average, the advent of the geared turbine being an interesting and pregnant development.

Where an electrical transmission system has been decided upon, the purchase of current demands first and careful consideration. If a private plant is to be installed then the generators may be either steam- or gas-engine driven. In the case of gas-engine driven generators the units may be of practically any size desired, while steam-engine driven units may be reciprocating engines up to 750 kw., and steam turbines thereafter. Interesting results can be got from the combination of reciprocating engines with steam turbines, a combination of this character giving a wide range of economical load at a modest capital cost. This advantage is obtained by cutting out the turbine from the lower loads and exhausting direct from the reciprocating sets to the condensers.

The sphere of usefulness of the large-power gas engine is confined mainly to situations where so called waste gas can be obtained, as at coke ovens and blast furnaces, or where a chemical plant is already installed.

In a works power plant the side issues also require consideration. The utilization of exhaust steam in turbines, of blast-furnace and coke-oven gas in large-power gas engines, and the development of the storage battery in connection with the fluctuating loads in large works, are all problems which warrant investigation.

Oiling the Largest Hydro-Electric Units

The power plant of the Mississippi River Power Co., now in course of construction at Keokuk, Iowa, will ultimately contain 30 generating units, with a rated capacity of 10,000 hp. each, at the normal head of 32 ft. At the maximum head of 39 ft. the output will be approximately 14,000 hp. each.

The waterwheels are the single-runner type and operate at 57.7 r.p.m. They are directly connected to vertical slow-speed generators. The turbines are the largest ever built and the plant is the first one of importance to contain slow-speed units.

All thrust bearings are a combination roller and oil-pressure bearing. As the total weight of the unit which each of these bearings supports is 275 tons, the importance of the oil supply is apparent. The oil is pumped to the bearings by Goulds triplex pressure pumps. It is supplied at a pressure of 250 lb. per sq.in., which is sufficient to lift each rotating member so that it floats on the oil and relieves the rollers of the load. These pumps have 6½-in. cylinders and 8-in. stroke and are operated by chain drive from line shafting.

The coal supply of Oklahoma is estimated to be ten billion tons. The state contains more than six million acres of coal-bearing land. Some of the land is estimated to be capable of yielding 7000 tons per acre.—"Coal Age."

The Prony Brake and Its Use

By H. M. Phillips

SYNOPSIS—An elementary explanation of the prony brake, common errors in its application and complete directions for using it correctly.

Most engineers consider themselves fairly familiar with the theory, if not with the practical use, of the prony brake; nevertheless, errors are common in its use. We know that a horsepower represents the performance of 33,000 ft.-lb. of work in one minute. If the work consists in lifting a weight, the simplest case, the weight times the number of feet through which it is lifted gives the foot-pounds. Now assume that the engine, motor, or other apparatus whose power is to be measured, is actually lifting a weight by means of a rope wound on a drum or pulley. The distance lifted per minute is obviously the circumference of the pulley (3.1416 times its diameter) times the number of revolutions per minute. Under ordinary conditions the weight would be lifted a considerable distance during the time required to take a satisfactory measurement; therefore, suppose that the pulley is allowed to slip so that the weight is suspended in air but remains stationary while the shaft revolves. The work done is the same as before, the weight is still being lifted, but merely falls back as fast as it is lifted. The manner in which the slip is accomplished, the size of the shaft, or other details have no bearing upon the amount of power required; the only essential is to obtain the speed at which the weight would be lifted if it were not allowed to slip back. In fact, all of the pulley except the hub and the point where the rope leaves its face could be cut away without altering the working conditions. We now approach the actual prony brake; it would, however, be very difficult to so adjust the brake friction as to keep a weight suspended in mid air without motion; hence the equivalent pull is measured by scales, or a spring balance, the latter for light loads.

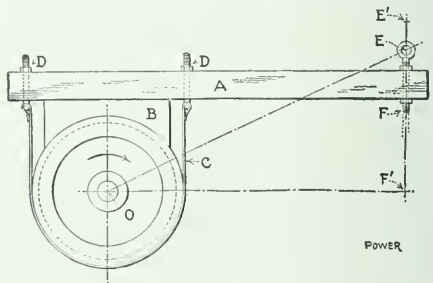
The construction of the brake varies considerably, being governed by the purpose for which it is intended, the material available, and the personal tastes of the designer, a common form is herewith illustrated, in which a wooden beam *A* has secured to it a block *B*, cut to fit the pulley: a band *C* is tightened on the pulley by the nuts *D*, the pull being measured by attaching a spring balance at *E* or allowing *F* to rest upon a scale platform.

For accurately determining the power absorbed by the brake, the number of revolutions per minute of the shaft, the length of the brake arm and the pressure exerted by the brake must be known. In determining the number of revolutions by the use of an ordinary revolution counter, some observers leave the counter in a little too long and obtain too high a reading, while others err in the opposite direction. If one is sure that the speed is constant he can detect this error by noting the revolutions for half a minute and then for a full minute or longer. If the counter is held in too long the half-minute reading will show the higher number of revolutions per minute, and *vice versa*. A number of readings should be taken to make sure that the difference is not purely accidental. Care should also be taken to hold the spindle of the counter in line with the shaft.

A tachometer is very convenient for determining the number of revolutions, but as it gets out of adjustment quite easily, some of its readings should be checked by a revolution counter.

Measuring the length of the arm is frequently a source of error, as it is often difficult to obtain an accurate measurement with the means at hand. Also, the proper points between which to make the measurement are mistaken by many; some imagine that the diameter of the friction pulley is to be considered in some way, but this has already been shown to have no bearing on the calculation.

Returning to the illustration and supposing the brake to be operated with its beam horizontal, the measurement is sometimes taken from the center of the shaft *O* to the points *E* or *F*, depending upon whether a spring balance or a scale is used. With all other conditions the same it is obvious that the balance would show the same reading whether the bolt were extended or the balance attached to a projection at *E* or lower; all these would give different measurements and consequently different results for the calculated horsepower. To determine the correct measurement, do not attempt to memorize or follow a fixed rule, but revert to the original theory. In the elementary case previously assumed, when hoisting the weight the pull of the rope must be tangential to the



Typical Prony Brake

pulley, or at right angles to the radius at the point of application. If we should hold the spring balance at right angles to the line *OE*, that measurement would fulfill the conditions and give a correct result, but it would be difficult to determine this position for the balance and practically impossible to arrange a scale to take the pressure in that direction. In setting up the brake the points *E* or *F* may be arranged to come on the same level as the center of the shaft, in which case the reading of the scale will be different from that obtained with the beam horizontal, and the measurement *OE* will be correct; the required conditions comparable to rope and pulley being fulfilled. Assume, however, it is desired to operate with the beam horizontal; then the distance *OF'* is the proper one to use in the calculations. With a plumb line locate the point on the beam that is directly over the center of the shaft and then measure along the beam to the line *EF*. It is also easier to set up the brake in this manner as one can judge with sufficient accuracy by the eye alone whether the beam is horizontal. On the other hand, it is not well to have too great a difference in level between the shaft and the points *E* or *F*.

In the calculations only the pull caused by the friction of the brake is considered, the scale reading due to the weight of the arm being deducted. This latter reading or "tare" may be determined in several ways; if the shaft revolves with considerable freedom, as with an electric motor, a reading may be taken while the pulley is at rest. An easy, although not absolutely accurate, method is to remove the brake arm and band from the pulley and support it by a bar while the reading is taken; in doing this, care must be taken to have the portion of the brake that is exactly over the center of the shaft rest upon the bar, in either case the weight must be taken with the beam in the same position, in which it is used during the test. Still another method is to loosen the brake band as much as possible and take a reading while running; then reverse the rotation and take another reading. Assuming the friction to be the same in each direction, half the difference of these two readings subtracted from the greater one gives the tare. In case the brake arm tends to rise when the rotation is reversed, sufficient weight may be added to keep it down during these two readings, the additional weight may be removed during the test. Tare may be eliminated by making the brake perfectly symmetrical about the shaft, but this tends to make it unnecessarily expensive and cumbersome.

Unless the action of the brake is perfectly smooth it is impossible to measure the pull satisfactorily; the spring balance is more apt to be affected by vibration than the scale, but has the advantage in some cases of allowing one to get at least a rough estimate of the pull where it would be impossible to obtain a scale reading. With a properly constructed brake, however, the scale will usually prove the more satisfactory. An oil dashpot attached to the brake arm will help, but to be effective it must be carefully adjusted, rigid and free from backlash. The tension on the brake band must be readily and quickly adjustable, for which purpose the use of a handwheel is preferable to a plain nut and monkey wrench. In any case care must be taken that the weight of the operator's hand or the pull he exerts in making adjustments is not registered on the scale. A satisfactory arrangement for light work is obtained by using a winged nut; by tapping this nut with a hammer very sensitive adjustment can be had.

To maintain a constant pressure on the beam the friction surfaces must not undergo any rapid changes during operation. To insure this they must be kept from overheating, lubrication must be maintained, and the pressure between surfaces must not be too great; failure in any of these will cause burning or cutting. In some cases the brake may be cooled by being flooded with water from a hose; this may be effective, but is apt to be hard on surrounding machinery and on the operator. Where possible a special pulley with inwardly projecting flanges should be used so that water may be carried inside the rim, centrifugal force holding it to the rim while the pulley is in motion. When a heavy load is carried an objectionable amount of steam may be liberated; in which event it is not difficult to provide water circulation and so keep the temperature below the boiling point. Pipe connections may be so arranged that one pipe will scoop water from the interior of the rim and carry it to a drain while another pipe introduces cold water.

Lubrication of the friction surfaces is necessary, and the material, shape and size of the rubbing surfaces are important in obtaining good lubrication. if the contact surfaces are too small they will be unable to carry away the requisite amount of heat, regardless of the cooling devices, and the temperature becomes too high for the oil; also, where excessive pressure is necessary the oil is unable to penetrate between the surfaces. The nature and shape of the material itself is important.

Very satisfactory results have been obtained with a band of ordinary sheet iron, as shown in the sketch, although such a brake would not carry as heavy a load as one with a different friction band. The load being light there is no great pressure between surfaces and the contact between the pulley and the band is irregular on account of the uneven surface of the latter. This is advantageous, inasmuch as it favors lubrication.

Two or more layers of heavy canvas between the band and the pulley will materially increase the capacity of this type. The canvas affords elasticity, gives a good bearing surface and acts as an excellent means of distributing the oil. It is generally possible to obtain satisfactory readings with this form of brake up to the point where the canvas is ignited by the heat of friction. Some of the more powerful brakes have wooden blocks secured to the band, similar to the brake frequently seen on a hoisting engine; but in this case the band usually nearly encircles the pulley, has its ends drawn together by bolts and has an arm secured to the band for weighing the load. The wooden blocks absorb oil and make an excellent friction surface, there is also ample opportunity to introduce oil or grease at almost any point.

A cheap temporary device for small pulleys may be made by using two blocks of wood cut to embrace a considerable portion of the circumference; a suitable arm is attached and the blocks tightened on the pulley by bolts. In this case it is well not to make too accurate a fit with the blocks; irregularities giving better opportunity for lubrication. Grooves may be cut in the blocks to further aid lubrication and cooling also if water is applied to the exterior of the pulley. In the latter case soap may be used as a lubricant; ordinary bar soap is cut in shavings and mixed with the water before it reaches the surface of the pulley; the water need be only moderately soapy to answer the purpose. For larger pulleys a sufficient number of strands of rope may be used in place of a band.

The capacity of a brake is always limited, for to absorb a definite amount of power it must be able to dissipate a definite amount of heat; but as the power is increased the point is approached where the cooling arrangements are unable to keep down the temperature. If the brake is to operate at a slow speed trouble may arise in attempting to get sufficient friction for the required pull without excessive pressure between the bearing surfaces, and unless the brake be properly designed its capacity will be limited by this fact rather than by heating; the capacity of such a brake will for a time increase directly in proportion to an increase in speed, but, however high the speed and perfect the lubrication, the point must finally be reached where the cooling device is inadequate. Several hundred horsepower may be absorbed by a brake constructed along the lines indicated.

While, theoretically, there is no reason why a brake should not be designed for any horsepower, if this runs too high the difficulty of providing proper lubrication increases, the apparatus becomes cumbersome and the cost prohibitive; in such cases special designs are used.

A detailed description of such brakes is beyond the scope of the present article, but a few words on the operating principle will suffice. In place of the pulley and band, revolving and stationary disks of thin sheet metal are used, these give considerable area of contact when pressed together and a number of pairs may be mounted on the same shaft without requiring excessive space. The disks may be provided with oil grooves and forced lubrication used if necessary. Also, the stationary disks may readily be arranged so as to have water circulation about the side not used as a friction surface, and as they are of thin metal the water will take up the heat very readily. We may go a step further and, using the disk as a diaphragm obtain any desired pressure on the friction surface by regulating the water pressure.

A much simpler arrangement which serves well for high, or moderately high, speed brakes is to make use of water friction for the braking effect. Such a brake may be made somewhat in the form of a single-stage Parson's steam turbine. On the rotating shaft a drum of any desired size is mounted which carries a number of rows of blades similar to the turbine blades, and an inclosing casing carries stationary blades of the same pattern, which enter with small clearance between the rows of revolving blades. Water introduced into this casing is subjected to a violent churning action. If the speed is sufficiently high the construction may be greatly simplified by doing away with separate blades and having water channels cast in the surface of the revolving drum, which enters with a small clearance into an inclosing cylinder provided with similar channels; clearance is provided all the way through so it is not necessary to have the cylinder in two parts. Water may be introduced conveniently by way of the interior of the rotating drum so that it will flow outward with centrifugal force. No lubrication is required, except for stuffing-boxes and bearings, and the same water provides both the friction and the cooling effects. If it is converted into steam no harm is done, although it is generally preferable to provide a sufficient flow of water to avoid this.

The principle of measuring the power is in no way changed, either with the water brake or the one previously described; in each case the pull is measured by a beam carried to scales and in each case the only factors to be considered in calculating are the amount of this pull, the distance, properly measured, from the center of the shaft to the point where the pull is weighed; and the speed at which the shaft rotates.

Condensing-Water Auxiliary Pump

By S. H. Farnsworth

A short time ago an article appeared in Power describing the Smoot-Rateau turbine installation at the southern works of the Illinois Steel Co.

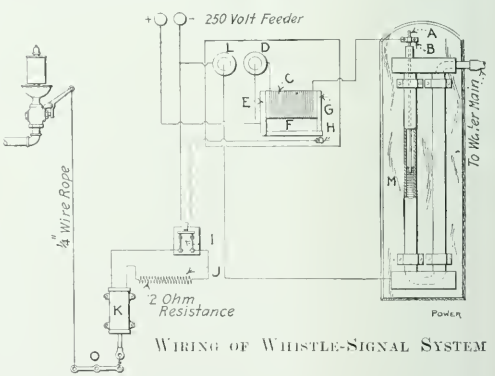
Engineers, knowing the important part fulfilled by the condensing apparatus in an installation of this kind, will be interested in the means of supplying water for it. The pumping station is about three-quarters of a mile from the turbine house and at the foot of the Worth Slip. It contains three DeLaval centrifugal pumps, driven by three 200-hp. Westinghouse, three-phase induction motors.

The building is of concrete and iron construction. The floor line is 10 ft. below ground and 5 ft. above the water level. A switchboard stands against the north wall. The knife switches are mounted above it. Each set is inclosed in a separate wooden case and operated from a platform parallel with and 10 ft. from the boxes.

In starting the motors, the 25-cycle, 2200-volt current is first sent through transformers and oil switches. When the motor comes up to speed the switch is released and 2200-volt current is cut in. This causes some shock and the wattmeter jumps to 300, but quickly settles down. About 40 amp. is the current required to carry the usual load. The motors are directly connected to the pumps, which are built for a 27-ft. head and each has a capacity, at 485 r.p.m., of 18,500 gal. per min.

Each discharge line has a swing-gate check valve and a hydraulically operated gate valve. A 1½-in. pipe leads from the top of the casing to an ejector, used for priming the pumps. The air is drawn out of the pump in about two minutes. The discharge lines from the three pumps join outside the station and then connect to a venturi meter.

When this station was first put into operation, trouble was experienced by the no-voltage release operating at most inconvenient times, stopping the pumps. The supply of cooling water being thus cut off, the condensers would be put out of service, further reducing the voltage. Therefore, these devices have been removed and now, if



Wiring of Whistle-Signal System

the voltage should drop below 800 volts, the switchboard operator notifies the engineer at the central pumping station to not build up the voltage until sure the pumps are running.

As this pumping station has no regular attendant a signal had to be devised to notify the engineer, when the head fell below a predetermined point. The device shown in the illustration was installed and gives good satisfaction. A 5-ft. U-tube is mounted on a board fastened to the wall. The right leg is connected by a hose to a ¼-in. water pipe leading to the water main beyond the venturi meter. The left leg has a rubber cork inserted, through which a length of No. 10 copper wire *A* passes down into the mercury with which the U-tube is half filled. The wire *A* is held in a bracket *B*, by a setscrew, so that by raising or lowering *A* its point of immersion is changed and the signal can be made to operate at any desired water pressure.

The bracket *B* is electrically connected to an electromagnet coil *C*, taken from a 50-hp. shunt-wound motor.

The other terminal of the coil is connected to a 125-volt lamp *D*. The other wire from *D* connects with the positive side of a 250-volt feeder. *E* is a piece of ¼x¾-in. steel fastened to the coil, but insulated from it. It is slotted to receive a ¼x¼-in. piece of steel, hinged at one end in *E*. *G* is a piece of ¼x¼-in. steel fastened to the coil. *H* is a nickel-steel contact piece in circuit with the switch *I* and resistance coil *J* and the solenoid *K*. The other side of *K* is connected directly to the negative side of the 250-volt feeder. A wire connects this feeder and the lamp *L;* the other side of *L* is grounded on the mercury column.

When the pumps are in operation and the pressure is normal, the mercury is raised in the leg *M* of the U-tube and makes contact with *A*. Current then flows from the positive feeder through the lamp *D*, coil *C* and bracket *B* to the mercury. Then into the grounded wire, then on up through the lamp *L* into the negative feeder. The coil *C* is thus energized and the lamps *L* and *D* are lighted. The armature *F* is raised by the magnetism in *G*.

When the water pressure decreases, the mercury recedes in the leg *M* of the U-tube until the wire *A* is out of contact with it. As the circuit is broken the coil *C* is de-energized and the armature *F* drops, making contact with *H*. Current then flows from the position feeder through *E, F, H, I, J* and *K* to the negative side of the line. This energizes the coil in *K* which raises the plunger and blows the whistle, the lever of which is connected to the arm *O*. A telephone line runs from the turbine station to the pumping station; but, owing to inductance, it is little use.

Another electric-driven pumping station is at the foot of the Southern Slip, about five miles south of the central pumping station. It contains two 30-in. centrifugal pumps driven by three-phase, 25-cycle, 2200-volt induction motors. These sets are used to supply water for barometric condensers, which require 30,000,000 gal. per 24 hr. When this station was first put into operation much trouble was caused by lack of a satisfactory priming device for the pumps. The nearest steam main is about two blocks away and the line had to run in such a tortuous and exposed way that the drop was excessive and unless the boiler pressure was better than 140 lb. the siphon would not work.

As a high-pressure fire main ran underground past the station it was decided to try water to work the siphon.

A system was perfected to prime the pumps with about 2.5-in. vacuum in the siphon suction leading from the pump. To get the siphon to work it was necessary to reduce the discharge nozzle until the water completely filled in, for, if eddies formed in the nozzle, air would find its way back to the suction line.

It was found that much better results were obtained by connecting the siphon suction into the suction casing directly over the center of the impeller shaft, instead of the top of the discharge casing. It seems that the impeller throws what water there is in the pump out against the discharge casing, leaving the air imprisoned in the center of the impeller. The discharge pipes contain check valves and electrically operated gate valves. They are fitted with safety circuit-breakers so that they cannot be opened or closed far enough to jamb.

The no-voltage release is so arranged that, when operated, it forms a circuit in a 250-volt line sounding a gong in the pump house and in the engine houses, giving notice to run noncondensing until the voltage is built up.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We hope you didn't dodge the foreword in this issue, "The Business End of the Power Plant." Dodging the business end of a mule is different; this foreword is a kick for you, not at you. Read it twice, digest this "food for thought," and pass it on to the man higher up. There'll be more along these lines in early issues, each with a punch in it. Watch out for 'em!

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And speaking of digestion, did you know that Horace Fletcher has just finished his Christmas dinner, thus beating last year's record by 4 days 6 hr. 7⅛ min.?

⁂

It is reported in political engineering circles that engineer Bryan, over to the Washington plant, is using grape juice as a throttle lubricant. When we indorsed the Wilson brand, we little thought that this Cabinet engineer would try to run on this grape stuff.

⁂

Great guns! Somebody claims that the modern cannon suggested the application of explosive gases in the driving of engines. Warlike implements have their victories no less renowned than peace.

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HELP WANTED!

By Billy Spills

A lady reader from Pennsylvania has suggested this picture as a fair sample of the difficulties encountered by the operating engineers in the Home plant. "If the engineer thinks his job is hard," writes friend lady, "how about the engineeress he leaves at home?"

Husbands and fathers, this looks like hard lines! Here's a seven-day, overworked isolated plant which must keep the consumers supplied while operating under great difficulties. Fix your eye on that little unit in the high chair; looks like a case of leaky condenser. The big lad has cut in with a troublesome bleeder. The superheater in the background has a leaky nipple. The supply man has butted in and invites the engineeress to make him shut down, shut up, and make 250 r.p.m. for the front gate.

And all these troubles seem to occur just at the peak of the load. Now that your eyes are opened, what are you going

A Busy Day at the Home Plant

to do to lighten the white woman's burden? What can be done?

We are dinged regretful that this column can only give publicity to this parlous state of affairs. At this writing there's a big suffragette parade going on in Noo York, and we will seek out the engineeresses, firewomen and coal-passettes division and see if "Votes for Women" has a remedy. But we balk at changing places with any Home plant engineeress, this is no remedy.

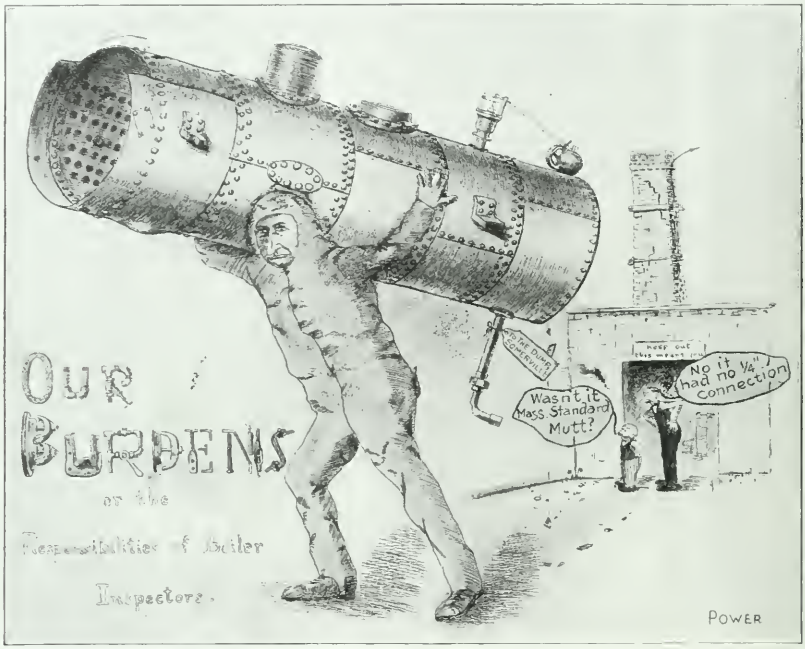
LATER—Found no operating remedy in the parade. Console yourself, dear lady, by the thought that "the hand that rocks the cradle rules the world"—and make the old man hustle for more "rocks!"

Boiler Inspectors' Dinner

Very substantial evidence of the growth of the American Institute of Steam Boiler Inspectors was had in the number attending its fourth annual dinner, Apr. 30. It was held in the Quincy House, Boston, Mass., and followed the business meeting and election of officers. The latter for the year 1913-1914, are W. O. Young, president; Herman Van Ormer, vice-president; John H. Gleason, secretary; Adam Oldfield, treasurer; F. G. Wright, E. J. Scanlon, E. R. Doherty, W. T. Eastman, H. H. Coyle, executive committee. Messrs. Young, Van Ormer, Gleason and Wright are with the Hartford Steam Boiler Inspection & Insurance Co., Mr. Oldfield, the Casualty Company of America; E. J. Scanlon, the Maryland Casualty Co., Messrs. Doherty and Eastman, the Mutual Boiler Insurance Co., and H. H. Coyle is with the Traveler's Insurance Co.

Prominent at the meeting and again at the dinner was the cartoon drawn for the occasion by James McDonald, and reproduced herewith, "Our Burdens." It was remarked by several that any boiler with single-riveted lap seams and double-riveted girth seams ought to be thrown out.

The list of speakers was so long that contrary to usual custom the first were called upon before coffee was reached, so, as at the three-ring circus, there was an embarassment



JAMES MCDONALD'S CARTOON, WHICH MADE ITS DEBUT AT THE BOILER INSPECTOR'S DINNER.
(Acknowledgment is made to Bud Fisher for the use of Mutt and Jeff)

ATTENDANTS AT THE DINNER OF THE AMERICAN INSTITUTE OF STEAM BOILER INSPECTORS

of riches—in good things to eat and good things to hear at the same time.

Andrew J. Savage, the veteran boiler inspector, oldest in the east, if not in the country, was the first heard from and received a warm ovation. It will be impossible to more than name the rest of the speakers who were as follows:

P. H. Hogan, past president of the National Association of Stationary Engineers; J. C. Shaw, president of the New York branch of the American Institute of Steam Boiler Inspectors; John A. Collins, secretary Mutual Boiler Insurance Co.; James Stewart, Stewart Boiler Works; G. Hill Smith, engineer; George B. Clark, Edgemoor Boiler Works; T. T. Parker, chief inspector, Fidelity & Casualty Co.; D. M. Dillon, Dillon Boiler Works; William Ranton; H. R. Cobleigh, "Power"; H. V. Brady, International Engineering Co.; Henry Lynch, representative of the Board of Boiler Rules of Massachusetts and with the Hodge Boiler Works; John A. Stevens; W. O. Young, the newly elected president; Charles Coopman, New England Iron Works; Professor J. C. Riley, Massachusetts Institute of Technology; J. G. Gillespie, Royal Insurance Co.; Robert Thompson, Traveler's Indemnity Co.; James White and Augustus Lloyd.

For an altogether highly successful and enjoyable evening much credit is due to Frank G. Wright, who acted as toastmaster, and to Herman Van Ormer, chairman of the entertainment committee, and T. G. Ranton, chairman of the educational committee.

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Explosion of Boiler Kills Owners

A steam boiler used to operate a pumping plant to raise water for irrigation purposes near Selma, Calif., exploded on the afternoon of Apr. 20, instantly killing Frank Rouch, the owner, and seriously injuring his son. The boiler was an old one and had formerly been used in a traction engine. There was no property loss exclusive of the boiler.

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Coming N. A. S. E. Conventions

A list of the Central States National Association of Stationary Engineers was published in "Power," of May 6. Below are additional conventions with cities and dates:

STATE CONVENTIONS

Newark, N. J., May 22 to 25.
Yonkers, N. Y., June 12 to 14.
Meriden, Conn., June 26 to 28.
Chester, Penn., June 27 to 28.
Lawrence, Mass., July 10 to 12.
Clarksburg, W. Va., ————— ————

NATIONAL CONVENTIONS

American Order of Steam Engineers, Philadelphia, Penn., June 2 to 7.

Canadian Association of Stationary Engineers, Owens Sound, Ont., July 29 to 31.

Universal Craftsmen, Council of Engineers, Boston, Mass., Aug. 4 to 9.

Eccentric Firemen's Association, Pittsburgh, Penn., Aug. 11 to 16.

National Association of Stationary Engineers, Springfield, Mass., Sept. 8 to 13.

Marine Engineers' Beneficial Association, Washington, D. C., Jan. 19 to 24, 1914.

International Union of Steam Engineers, Peoria, Ill., September, 1914.

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A. S. M. E. Baltimore Program

The spring meeting of the American Society of Mechanical Engineers will be held at Baltimore, Md., May 20-23, at the invitation of the Engineers' Club of Baltimore and the local members. The professional sessions have been arranged as usual, while all other events are in charge of the local committee under the chairmanship of Layton F. Smith, past president of the Engineers' Club of Baltimore.

THE PROGRAM

Tuesday, May 20—Registration of members and guests at headquarters, Hotel Belvedere.

Tuesday Evening—Membership reunion and informal reception.

Wednesday, May 1—Business Meeting, 9:30 a.m.: Report of tellers of election of members. Announcement of ballot on amendments to the constitution relating to membership grades. New business.

Reports of special committees on Myriawatt, Involute Gears, Standardization of Catalogs, Code of Ethics and National Museum. Simultaneous sessions following business meeting.

Professional Session—Papers: "Test of a Hydraulic Buffer," Carl Schwartz; "The Present Condition of the Patent Law," Edwin J. Prindle; "Shading in Mechanical Drawing," Theodore W. Johnson; "Cost of Upkeep of Horse-Drawn Vehicles against Electric Vehicles," W. R. Metz.

Gas-Power Session—Business meeting. Paper, "Present Operation of Gas Engines Using Blast-Furnace Gas as Fuel," Charles C. Sampson.

Wednesday Afternoon—Demonstration of the high-pressure fire system at City Hall plaza, and inspection of pumping station, followed by a sail about the harbor to inspect the water front, shipping facilities, and other features of interest.

Wednesday Evening—Lecture, illustrated by lantern views: "Around the World in Eighty Minutes," Hon. O. P. Austin, secretary, National Geographic Society.

Thursday, May 22—Fire Protection Session, 9:30 a.m.: "The Baltimore High-Pressure Fire Service," James B. Scott; "National Standard Hose Couplings and Hydrant Fittings for Public Fire Service," F. M. Griswold; "Department of City Conflagrations," Albert Blauvelt; "Allowable Height and Area in Factory Buildings," Ira H. Woolson; "The Protection of Main Belt Drives with Fire Retardent Partitions," C. H. Smith; "The Life Hazard in Crowded Buildings Due to Inadequate Exits," H. F. J. Porter.

Thursday Afternoon—Inspection of sewage pumping plant, Jones Falls conduits, and trip by trolley to sewage-disposal plant at Back River. Automobile trips for ladies, about the city and suburbs, with tea served at the Country Club.

Thursday Evening—Reception and dance. The society will be the guests of the Engineers' Club of Baltimore on this occasion.

Friday, May 23—All-day excursion at Annapolis, and the U. S. Naval Academy with a reception by Governor Goldsborough at the State House. After the reception the party will proceed to the Assembly Chamber where Admiral H. I. Cone, engineer-in-chief of the Bureau of Steam Engineering, U. S. N., will deliver an address upon the United States Experimental Station at Annapolis. Luncheon will be served at the Carvel House. In the afternoon, there will be a band concert by the Naval Academy Band, and a dress parade at 6 o'clock, which may be witnessed by those finding it convenient to remain. It is expected that there will be hydro-aëroplane flights by officers and men of the aviation school, and evolutions of the submarine boats stationed at Annapolis.

⁂

N. A. S. E. Business Legalized

A bill to legalize the conventions and business transactions of the National Association of Stationary Engineers, when such transactions were made outside the state of New York, recently passed the New York Legislature.

Although no conventions or business transactions outside this state were questioned, the officers felt that it was best to legalize all past and pending business in states other than New York.

⁂

Dinner to Prof. Hollis

On Tuesday evening, Apr. 29, a dinner was given in honor of Prof. Ira N. Hollis, formerly of Harvard University and recently appointed to the presidency of Worcester Polytechnic Institute. The members of the Boston sections of the American Society of Mechanical Engineers, the Civil Engineers and the American Institute of Electrical Engineers gave the dinner, which was held at the Boston City Club. Among other distinguished educators present were Dr. Richard C. MacLaurin, president of Massachusetts Institute of Technology, and Dr. A. Lawrence Lowell, president of Harvard university.

At the conclusion of the dinner two papers, illustrated by lantern slides, were presented, "Some Phases of the Development of the Grand Central Terminal," by George W. Kittredge, chief engineer of the New York Central Lines, and "Problems in Local Transportation," by Matthew C. Brush, second vice-president of the Boston Elevated Ry. Co.

⁂

W. A. Bone, of the University of Leeds, and C. D. McCourt, of London, have taken out an English patent upon a grate or hearth for the application of the Bone system of surface combustion to an ordinary furnace.

Exaggerated Flood Reports

The Platt Iron Works Co., Dayton, Ohio., is another company whose condition has been exaggerated by recent flood reports. B. K. Gantt writes as follows:

"While it is true that we have suffered considerable damage, our buildings were practically uninjured and we have recovered more quickly than we anticipated. The second day after the water subsided we had steam up and the work of removing the mud and débris was started. Our entire organization responded most loyally toward getting the plant in operation, irrespective of the fact that many of them suffered personal loss due to the flood. A small portion of our plant was put in operation Apr. 7 but as a large number of our machine tools are equipped with individual motor drives we were obliged to bake and clean these motors and did not start up in all departments until Apr. 21. We are now prepared to accept and fill all orders promptly."

Bureau of Licenses Not to Inspect Boilers

During the last session of the New York Legislature, Senate bill No. 2499, which, in effect, was to permit New York City to transfer the duties of boiler inspection and the licensing of engineers and firemen from the Police Department to the Bureau of Licenses was not "brought out of committee." It is considered that the bill will now be lost by default.

Hydro-Electric Enterprise in Italy

It is reported that arrangements have been completed for carrying out several important hydro-electrical projects in Italy. The Societa per le Forze Idrauliche della Sila is about to erect a large power station in southern Italy to generate 50,000 hp. The generating station will be at Cosenza, in Calabria, and part of the power will be consumed on the spot for the manufacture of calcium carbide, the remainder being transmitted by cables to various centers. The preliminary capital will be about $8,000,000. If necessary the water power available can be made to generate 150,000 hp. A power station is also being erected in Sardinia to electrify the power of the River Tirso. About 15,000 hp. will be generated, and will be taken by the numerous mines in the district.

A new generating plant is being laid down in northern Italy by the Societa Ligure Toscana di Elettricita. The new station will generate 15,000 hp.

The State railway authorities have just entered into a contract for the supply of power in connection with the electrification of the Ronco-Sampierdarena-Genoa line. The power station will be completed in a few months and will generate about 50,000 hp.

In central Italy, too, several hydro-electrical power stations are to be erected. The water power in central Italy is said to be considerable, representing close on 400,000 hp.

SOCIETY NOTES

The institution of Engineers and Shipbuilders in Scotland and the Institution of Naval Architects have arranged a joint summer meeting, which is to be held in the rooms of the Scottish Institution, Elmbank Crescent, Glasgow, on June 24, 25, 26 and 27.

The eighteenth annual convention of the National Association of Manufacturers will hold its annual convention on May 19, 20, 21, at Detroit, Mich. This organization, composed of 4000 of the largest firms in the country, has in recent years held its annual sessions at New York, the importance of its discussions and the prominence of its speakers attracting an attendance of approximately a thousand representatives of large employers throughout the United States.

The proceedings of the association this year will be of exceedingly great interest to manufacturers and employers everywhere on account of the change in the national administration, the application of new tariff schedules, the legislative enactments designed for the regulation of business, both big and little, the general economic unrest, and the ever-sharpening aspects of the labor situation. The convention, which will be at the Hotel Pontchartrain, will witness the inauguration of many new policies and plans for the betterment of industry, notable features being addresses and reports on accident prevention and workmen's compensation, industrial education, fire prevention, export trade, patent reform, currency and banking, immigration, interstate commerce and federal incorporation, consular reform, bankruptcy, uniform state laws.

The opening address will be by Mayor Oscar B. Marx, of Detroit, followed by an address of welcome by James Couzens, president of the Detroit Chamber of Commerce.

In connection with the report of the Committee on Accident Prevention and Workmen's Compensation there will be a notable exhibit of safety devices: Ferd. C. Schwedtman, chairman of the committee, will deliver an address, incidental to which lantern slides and moving pictures will be shown, followed by a discussion by J. A. Robertson, of the Eastman Kodak Co., Rochester, N. Y.; J. P. Douglas, of the United Gas Improvement Co., Philadelphia, Penn., and L. B. Robertson, of the Ford Motor Co., Detroit, Mich., and others. The session devoted to industrial education will consist of a report by the committee and addresses by H. E. Miles, chairman, and Dr. John H. Leete, Dean of the School of Applied Science of the Carnegie Institute of Technology, Pittsburgh, Penn.

PERSONALS

J. K. Haigh, for 10 years connected with the Snow Steam Pump Works in Buffalo, has been transferred to the company's Los Angeles office.

The Hon. William C. Redfield has resigned as vice-president and a director of the American Blower Co., Detroit, Mich., since his appointment as Secretary of Commerce in President Wilson's cabinet.

John Hays Smith, commercial engineer of the Milwaukee Electric Ry. & Light Co., in charge of engineering and sales of electric power and steam heat, has resigned to engage in consulting engineering, with offices in the Merrill Building, Milwaukee. Before coming to Milwaukee Mr. Smith was with the Duquesne Light Co., Pittsburgh, and was with the Westinghouse Electric & Manufacturing Co. for seven years.

A Diesel Engine, built by the Busch-Sulzer Bros. Diesel Co., St. Louis, Mo., for the Hugo, Oklahoma, Ice & Light Co., was tested recently by A. T. Scott, Dallas, Tex. The engine is a three-cylinder machine, rated at 225 net b.hp., direct connected to a generator. The fuel consumption in various rates of output was as follows:

Net brake hp.	Oil burned per net brake hp.-hour, lb.
49.7	0.769
111.39	0.482
162.97	0.454
219.63	0.441
245.6	0.444

The air compressor furnishing the air for starting the engines and injecting the fuel supply was driven by power from an independent source. The current used to drive this compressor was deducted from the output of the generator to obtain the net brake-horsepower. The engine tested had been in operation for six months. The oil used showed on analysis 18,986 B.t.u. per lb. of oil; the specific gravity was 0.8531, and it had a viscosity of 92 degrees F. of 1.63. Analysis of the exhaust gases showed that no combustibles remained in them.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Buzzards Bay Electric Co. has been granted a franchise to construct and operate an electric-light plant at Chatham, Mass. H. H. Taylor, Falmouth, Mass., is superintendent.

Plans are being prepared by the Berkshire St. Ry. Co. for the construction of a new substation at Lee, Mass. C. L. Richmond, Pittsfield, Mass., is general manager.

A committee has been appointed to investigate the feasibility of installing a water system at Somerset, Mass. D. B. Davis is town clerk.

The city council of Chambersburg, Penn., is considering the proposition to appropriate $30,000 for the improvement of the municipal electric-light plant and the installation of new equipment.

The village authorities of Lawrenceville, Penn., are considering plans for the installation of a water system.

POWER

Vol. 37 NEW YORK, MAY 20, 1913 No. 20

THEY ARE BOTH FINE HORSES BUT THEY PULL BEST HITCHED DOUBLE

The First American Locomobile

By F. R. Low

SYNOPSIS—A self-contained superheated steam-driven unit which turns out an indicated horsepower on a trifle over a pound of coal per hour, in sizes of less than 200 horsepower capacity.

Take a high-class compound engine, mount it upon its boiler, so that the cylinders are in the smoke box and the steam passes from the superheater directly to the high-pressure cylinder, and from the high-pressure through a reheater directly to the low without extraneous piping. Run the condenser and feed pumps from the engine itself so that the unit constitutes a complete steam plant with all its accessories, and you have what has been known for years in Europe as a "locomobile."

old throttle-valve engine was limited and built the first automatic cutoff engine west of the Alleghanies, which built the first American steam-engine indicator, which was the first American shop to use blueprints, which was close upon the heels of the gas-engine development, and which has always been upon the firing line of progress, the Buckeye Engine Co., of Salem, Ohio.

Whence the "Buckeyemobile," as their new product is destined to be known. For more than a year they have been at work developing and testing out the new machine, and would not allow attention to be directed to it until it had demonstrated its practicability and worth by months of service.

Fig. 1 is an exterior view of the unit, the makeup and

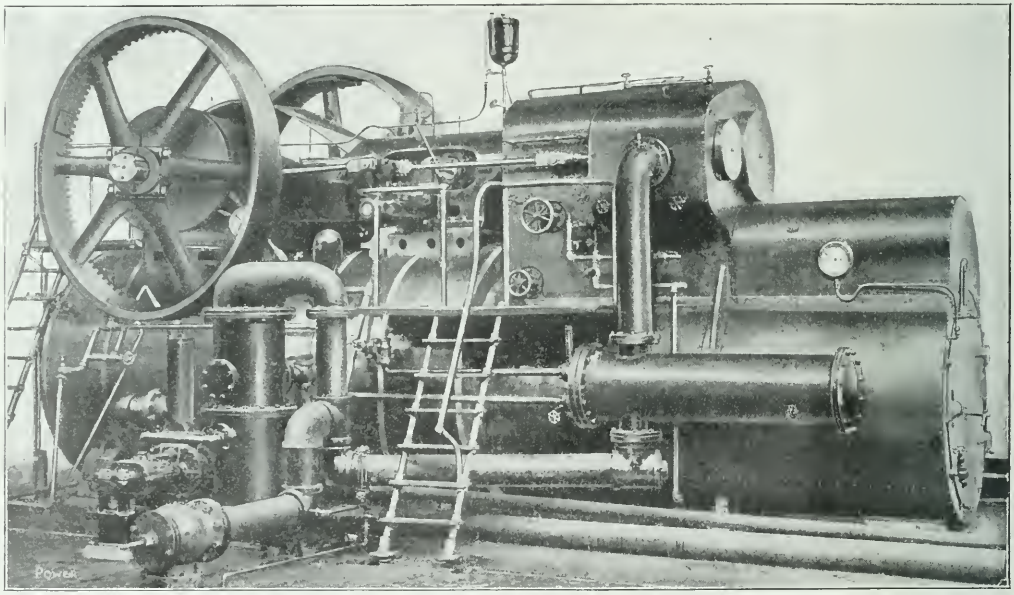


FIG. 1. THE BUCKEYEMOBILE OR FIRST AMERICAN LOCOMOBILE ON TEST FLOOR

The amount of fuel used by these units is surprisingly small, and it was the adoption of a self-contained steam plant of this sort for its propulsion that gave the name Locomobile to a well known American motor car. These units, not at all of the rough-and-ready order of the ordinary portable outfit, but highly finished and adapted to the ornate surroundings of the high-class continental power plant, are in very common use abroad. Much has been published in POWER and elsewhere concerning their performances, and wonder has been expressed that no American manufacturer has undertaken to supply them.

It has at last been our pleasure to see a real locomobile built by American engineers in an American shop, and it is logical and natural that this shop should be that of the company that early recognized that the field of the

component parts of which will be understood from the plan, elevation and longitudinal cross-section in Figs. 2, 3 and 4, and from the views of the dismantled engine shown in the other reproduced photographs.

Referring first to Fig. 4, the gases, after passing through the boiler tubes, impinge upon the superheater which consists of a continuous coil of seamless drawn-steel tubing, 3 in. in outside diameter, shown in place in Fig. 5, and then through the reheater, consisting of loops of 1-in. seamless tubing expanded into headers, as shown in Fig. 6, after which they escape by the discharge passage as indicated. The space above the superheater and reheater is not shut off and the gases are free to rise around the cylinders and connecting piping. No attempt has been made to heat the feed water with the gases.

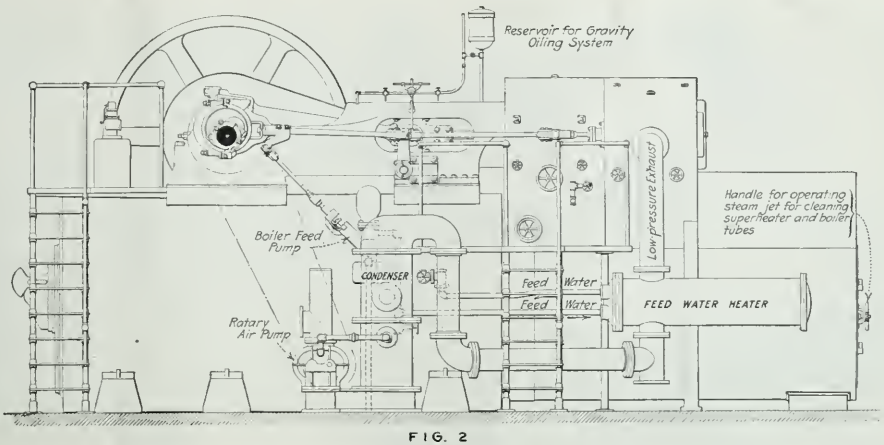


FIG. 2

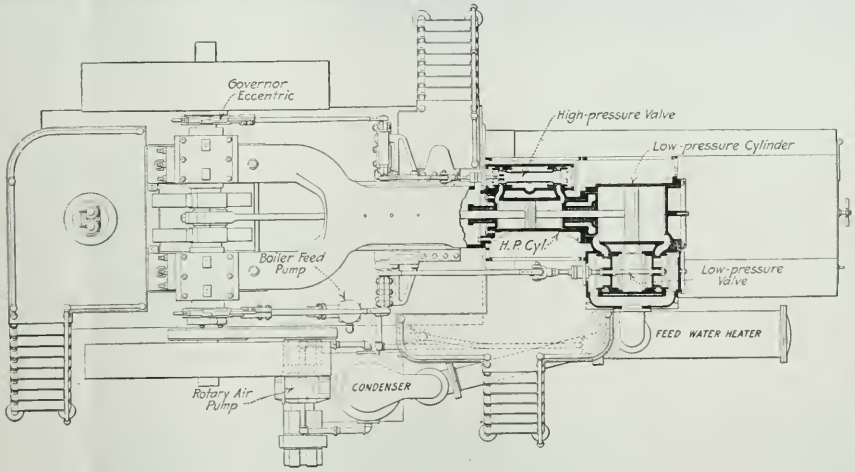


FIG. 3

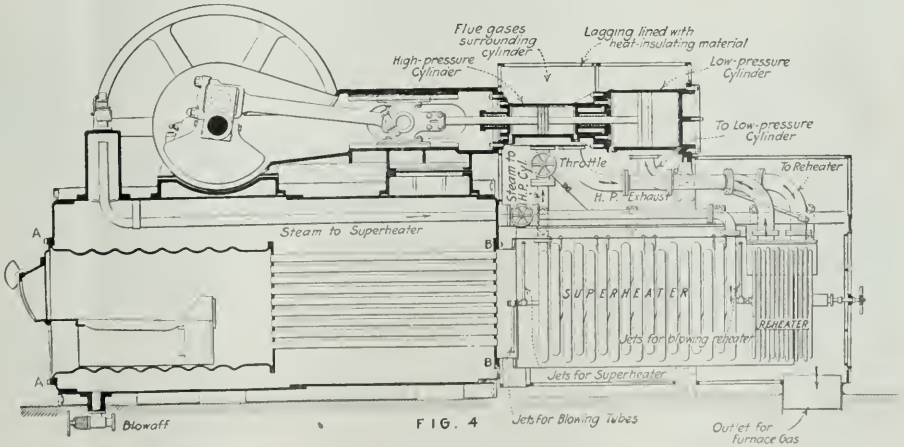


FIG. 4

ELEVATION, PLAN AND LONGITUDINAL SECTION OF THE FIRST BUCKEYEMOBILE

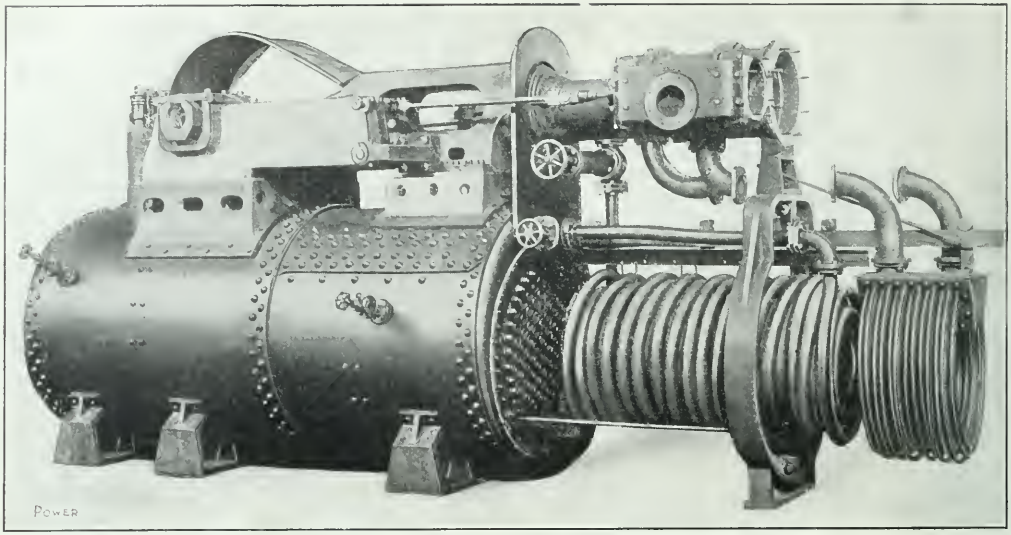


FIG. 5. BUCKEYEMOBILE STRIPPED OF LAGGING, JACKET, ETC.

The steam is taken from the steam dome, and passes, as shown in Fig. 4, into the far end of the superheater, returning in a direction counter to that of the gas flow, passing into the high-pressure cylinder just after contact with the hottest gases. Leaving the high-pressure cylinder it passes through the reheater and to the low-pressure cylinder, whence it is discharged through the feed-water heater to the condenser.

As is consistent with a self-contained unit the boiler is internally fired, requiring no setting, avoiding losses from air infiltration, etc. It is significant of the economy of the combination that with the steam furnished by this little boiler, having only 9 sq.ft. of grate surface and about 370 sq.ft. of heating surface, the unit has turned out 200 indicated horsepower.

By unbolting the flanges *A* and *B*, Fig. 4, the furnace and tubes can be removed, as shown in Fig. 7, for cleaning and inspection. This is no new expedient, but has been for years in successful use in German locomobiles.

The boiler is built in two courses of 7/8-in. sheets supported by three cradle brackets on each side, as shown in Fig. 7, and carries at its center a massive saddle which

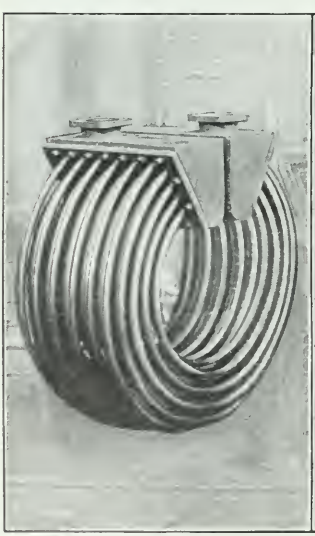


FIG. 6. REHEATER

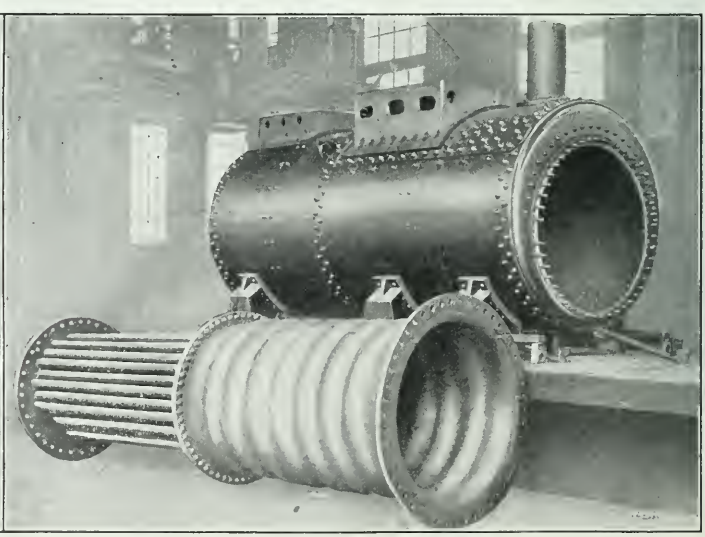


FIG. 7. BOILER WITH FURNACE AND TUBES REMOVED

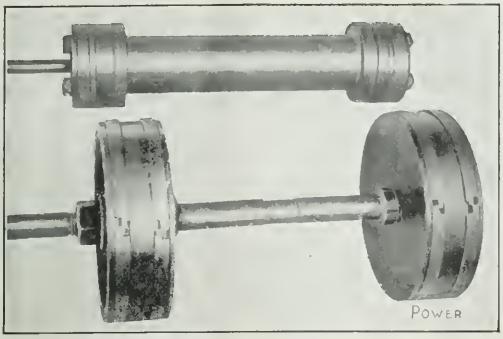


FIG. 8. VALVES AFTER MONTHS OF USE

spans about one-third of its circumference. To this the engine bed is rigidly secured at the main bearing end. The guide-barrel end rests upon a smaller saddle at the rear end of the boiler and is free to slide thereon, avoiding stresses from unequal expansion of the boiler and the

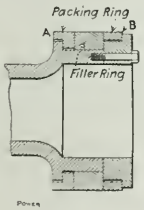


FIG. 9.

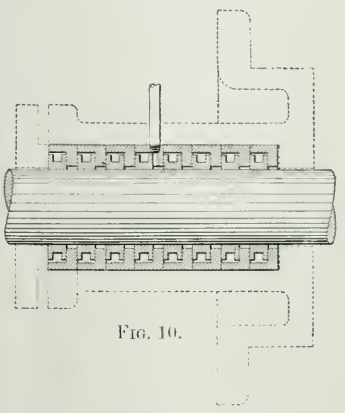


FIG. 10.

engine frame. The engine cylinders overhang the rear end of the boiler and are supported by a frame carried upon the foundation, as shown in Fig. 5.

The high-pressure cylinder is nearest the frame and the throttle valve is brought to the outside of the casing by extending its bonnet, as shown in the same view. It is again significant of the small steam requirements of the engine that this throttle valve is only 3 in. in diameter, while the valve between the boiler and the superheater is only 2½ in. The heaters are seen to be freely suspended in the path of the gases, and steam blowers indicated in Fig. 4 (the operating handle of which is seen at the right-hand end of the boiler) are provided to clean the surfaces when in operation.

The engine is shown in horizontal and vertical section in Figs. 3 and 4. The cylinders are 9½ and 19 in. in diameter, stroke 18 in., speed 200 r.p.m. Normal rated capacity 175 ultimate, 235 i.hp. Piston valves are used, taking the steam in the center and exhausting at the ends. A photograph of these valves taken after two months of use is reproduced in Fig. 8. The writer saw them after they

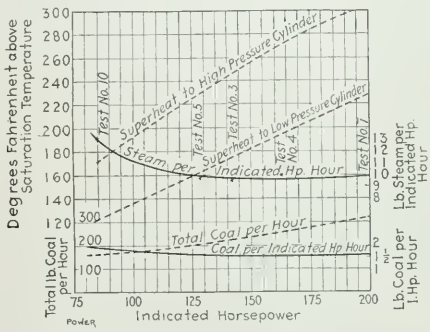


FIG. 11. TEST RESULTS OF BUCKEYEMOBILE

had been used for several months, and, although they have been used with high degrees of superheat, they show no evidence of lack of effective lubrication. Positive feed lubrication with leading pipes whereby the oil is discharged directly upon the surfaces to be lubricated is used for the high-pressure cylinder while for the low-pressure the oil is fed in with the steam. A simple and effective gravity-oiling system takes care of the bearings, all the oil used being gathered at one point and passed through a filter preparatory to being used over again.

As the rings in the valves constitute the working edges, those on the inside controlling the admission to the high-pressure cylinder are made of the section shown in Fig. 9, giving a sharp unobstructed edge at *A* for admission and cutoff. The control of release and compression by the edge *B* of the other ring or of the valve need not be so abrupt. The high-pressure valve is hollow and symmetrical with thin walls, conducive to keeping its shape under temperature variations, and its interior is filled with exhaust steam, which aids in keeping its temperature within limits. The packing used upon the rods and

RESULTS OF SPECIAL TESTS OF BUCKEYEMOBILE

No.	Date		Speed, r.p.m.	I.hp.	B.hp.	Mean Effective Pressure: Mech. eff., per cent.	Mean Effective Pressure: High-pressure cylinder	Mean Effective Pressure: Low-pressure cylinder	Mean Effective Pressure: Referred to low-pressure	Water: Per b.hp.-hr., lb.	Water: Per i.hp.-hr., lb.	Coal: Per b.hp.-hr., lb.	Coal: Per i.hp.-hr., lb.	Pressure: Avg. boiler press., lb. gage	Pressure: Avg. vacuum, in.	Superheat: High-pressure cylinder, F. deg.	Superheat: Low-pressure cylinder, F. deg.	Length of run, hr.	Coal
3	Oct.	14	195.5	142.2	127	89.3	67.5	12.02	28.47	10.82	9.65	1.75	1.56	196.5	27.15	256	214	3	Slack & Holwick
1	Oct.	25	197.6	162	148	91.35	73.6	14.2	32.15	11.08	10.01	1.65	1.51	206.5	26.62	273	193	2	Holwick
5	Oct.	26	205.5	128.2	115	89.7	58.9	10.1	24.12	10.9	9.78	1.8	1.61	201.5	28.58	227.6	164.1	3.4	Pittsburgh
6	Oct.	28	205.9	163.5	154	94.18	71.7	13.7	31.2	11.45	10.8	1.72	1.62	198.5	27.27	273.5	196	4.1	Pittsburgh
7	Oct.	29	206.6	200	192	96	83.2	17.9	38.11	10.25	9.9	1.67	1.6	201	27.23	302	229	3.05	Pittsburgh & Holwick
10	Nov.	6	205.6	84.6	77	91.01	9.5	6.6	16.1	14.65	13.3	2.14	1.95	200	27.75	170.1	119.5	3	Holwick
					kw	overall efficiency	load factor					per kw.-hr.							
11	Mar.	30	206		150.2	93.1	83.4					2.99	1.856	208		262	189	3.5	Salem, good quality
12	Mar.	30	206		160.1	95.6	80.04	76.5%				2.35	1.40	208.5	23.25	263	189	3	Salem, good quality

Daily Summary of the Performance of the Buckeyemobile on Shop Load

Date	Time Start	Time Stop	Hr. Run	Total Lb. Coal	Coal per Hr.	Total Kw. Hr.	Aver. Load, Kw.	Load Factor, Per cent.	Coal per Kw.hr.	Coal per I.hp.hr.	Method of Operating	Average* Vacuum	Remarks
Jan. 30.	8:30 a.m.	5:33 p.m.	9	2260	251	715	79.5	63	3.16	1.84	Condensing	..	Salem Mine coal.
Feb. 10	12:30 p.m.	5:30 p.m.	5	1486	297	465	93.0	74.4	3 20	1.895	Condensing	..	Salem Mine coal. Poor grade. Full of dust.
Feb. 11 ...	12:30 p.m.	5:30 p.m.	5	1474	295	480	96	76.8	3 12	1 93	Noncoodensing	.	Pittsburgh coal. 14,348 B.t.u.
Feb. 12.	12:30 p.m.	5:30 p.m.	5	1232	246 5	440	88	70.5	2 8	1 65	Condensing		Pittsburgh coal. 14,348 B.t.u.
Feb. 14 .	12:30 p.m.	5:30 p.m.	5	1301	274	465	93	74 4	2 95	1 75	Condensing		Pittsourgh coai. 14,348 B.t.u.
Feb. 15..	8:00 a.m.	11:33 p.m.	$3\frac{1}{2}$	782	227	285	81 4	65	2 745	1 63	Condensing		Pittsourgh coal. 14,348 B.t.u.
Feb. 17	8:00 a.m.	5:30 p.m.	$7\frac{1}{2}$	1900	245	720	93	74 4	2 64	1 56	Condensing		Holwick coal. 14,398 B.t.u.
Feb 20...	1:45 p.m	5:33 p.m.	$3\frac{1}{2}$	1088	290	325	86 7	69 3	3 35	1 97	Condensing		Salem (full of dust) 13,843 B.t.u.
Feb. 21	1:05 p.m	5:30 p.m.	$4\frac{1}{2}$	1279	290	400	90 6	72 5	3 195	1 89	Condensing		Salem (much dust) 13,843 B.t.u.
Feb. 24....	6:30 a.m.	5:30 p.m.	10	3032	303 2	925	92 5	74	3 59	1 94	Condensing		McNab hard coal. 14.09% ash. 12,723 B.t.u.
Feb. 25.	8:10 a.m.	2:30 p.m.	$5\frac{1}{2}$	1290	242	433	81 2	65	2 98	1 74	Condensing		
Feb. 25	2:30 p.m.	4:30 p.m.	2	525	262 5	186	93	74 4	2 82	1 68	Condensing		McNab hard coal and Salem coal, 75% and 25% resp.
Feb. 26.	6:30 a m.	5:30 p.m.	10	2548	254 8	865	86 5	69 2	2 94	1 73	Condensing		Salem coal. Run of mine. 13,843 B.t.u.
Feb. 27	6:30 a.m.	5:30 p.m.	10	2892	289.2	990	99	79	2 93	1 74	Condensing		Salem coal. Slack. 13,760 B.t.u.
Feb. 28.	6:30 a.m.	5:30 p.m.	10	2683	268 3	915	91 5	73 2	2 935	1 74	Condensing		Salem coal. Slack. 13,760 B.t.u.
Mar. 1	6:30 a.m	11:30 a.m.	5	1301	260	460	92	73.5	2 83	1 68	Condensing		Salem coal. Run of mine. 13,912 B.t.u.
Mar. 3	8:10 a.m	5:30 p.m.	$8\frac{1}{2}$	2341	281	780	93 6	74 8	3 00	1 78	Condensing		Salem coal. Run of mine. 13,912 B.t.u.
Mar. 4	6:30 a m.	5:30 p.m	10	2805	280	980	98	78.4	2 86	1 706	Condensing		Salem coal. Run of mine. 13,912 B.t.u.
Mar. 5 .	6:30 a.m.	5:30 p.m.	10	2717	271 7	870	87	69 6	3 12	1 84	Condensing		Salem coal. Run of mine. Contains slate. 13,912 B.t.u.
Mar 6	6:30 a.m.	5:30 p.m.	10	2641	264 1	876	87 6	70	3 02	1 78	Condensing	..	Salem coal. Run of mine. Rogers coal. In use at 11 a.m. 13,912 B.t.u.
Mar. 7	6:30 a.m.	5:30 p.m.	10	2589	258 9	845	84 5	67 6	3 06	1 80	Condensing	.	Rogers Ohio 13,515.37 B.t.u.
Mar 8	6:30 a.m.	11:30 a.m.	5	1120	260	390	78	62 4	2 87	1 936	Condensing	..	Rogers Ohio coal mixed with Salem run of mine.
Mar 10	6:30 a.m.	5:30 p.m.	7	1753	251	600	85.4	68 3	2 92	1 735	Condensing	$24\frac{1}{2}$	Salem run of mine. 13,843 B.t.u. Salem slack. 13,760 B.t.u.
Mar. 10	12:30 p.m.	3:30 p.m.	3	785	262	270	90.0	72	2.91	1 805	Noncondensing		Salem run of mine. 13,843 B.t.u. Salem slack. 13,760 B.t.u.
Mar. 11	6:30 a m.	5:30 p.m.	7	1724	246	525	75	60	3 30	1 85	Condensing	$23\frac{1}{2}$	Salem run of mine. Salem slack (full of dust). Rogers Ohio lump.
Mar 12	6:30 a.m.	5:30 p.m.	10	2566	256	770	77	61 3	3 33	1 93	Condensing	$23\frac{1}{2}$	Salem run of mine. Salem slack (full of dust.)
Mar. 13	6:30 a m.	5:30 p.m.	10	2529	252 9	745	74 5	59 6	3 39	1 96	Condensing	$22\frac{1}{2}$	Salem slack. Full of dust and much dirt. 13,760 B.t.u.
Mar. 14	6:30 a.m.	5:30 p.m.	10	2035	203 5	770	77	61 3	2 64	1 53	Condensing	$22\frac{3}{4}$	Salem run of mine. 13,843 B.t.u. Good coal. Free from dirt.
Mar. 21	8:30 a.m.	5:30 p.m.	8	2312	289	730	91 25	72 8	3 17	1 965	Noncondensing	.	Rogers Ohio coal. Full of dust and dirt. 13,515 B.t.u.
Mar 22.	6:30 a m.	11:30 a.m.	5	1423	284 6	415	83	66.5	3 44	2 12	Noncondensing	. .	Rogers Ohio coal. Full of dust and dirt. 13,515 B.t.u.
Mar. 24 .	6:30 a.m.	5:30 p.m.	10	3502	350 2	840	84	67.2	4 16	2 57	Noncondensing	. .	Rogers Ohio coal. Full of dust and dirt. 13,515 B.t.u.
Mar. 25	2:00 p.m.	5:30 p.m.	$3\frac{1}{2}$	1000	285 5	345	98 6	78 8	2 90	1 82	Noncondensing	.	Salem mine coal. 14,000 B.t.u. Good quality, free from dirt.
Mar. 26	6:30 a m	5:30 p.m.	10	2991	299 1	1005	100 5	80 4	2 98	1 785	Noncondensing		Salem mine coal 14,000 B.t.u. Good quality.
Mar 27	6:30 a.m	5:30 p.m.	10	2920	292	950	95	76	3 08	1 83	Noncondensing	. .	Salem mine coal. 14,000 B.t.u. Good quality. No dirt.
Mar. 28 .	6:30 a.m.	5:30 p.m.	10	2920	292	890	89	71 2	3 28	1 94	Noncondensing	.	Salem mine coal. 13,750 B.t.u. Rodgers Ohio coal.
Mar. 29	6:30 a.m.	11:30 a.m.	5	1371	274 2	430	86	68 8	3.19	1 97	Noncondensing		Salem mine coal. 13,750 B.t.u. Rodgers Ohio coal
Apr. 1	6:30 a.m.	5:30 p.m.	$8\frac{1}{2}$	2134	251	760	89 4	71 5	2 81	1 67	Condensing	$24\frac{1}{2}$	Salem coal. 14,000 B.t.u. Good quality no dirt.
Apr. 2**	7:30 a.m.	5:30 p.m.	9	2260	251	830	92 2	73 8	2 72	1 615	Condensing	$24\frac{1}{2}$	Salem coal, 14,000 B.t.u Good quality. No dirt.
Apr 8**.	2:35 p.m.	5:05 p.m.	$2\frac{1}{2}$	697	278	220	88	70 4	3 16	1 77	Condensing	$24\frac{1}{2}$	Salem mine. Stoker fired. Good quality. 14,000 B.t.u.
Apr. 9..	9:10 a m.	5:30 p.m.	$7\frac{1}{3}$	1838	252	620	84 6	67 6	2 97	1 725	Condensing	$24\frac{1}{4}$	Shepherd coal, Salem, O. Stoker fired.
Apr. 10	3:15 p.m.	5:30 p.m.	$2\frac{1}{2}$	621	276	210	93 4	74 8	2 95	1 815	Noncondensing	.	Salem coal. 14,000 B.t.u. Good quality. Stoker fired.
Apr 11	1:50 p.m.	5:30 p.m.	$3\frac{1}{2}$	829	237	325	92 8	74 2	2 55	1 515	Condensing	$23\frac{1}{4}$	Salem coal. 14,000 B.t.u. Good quality. Stoker fired.
Apr 12	6:30 a.m.	11:30 a.m.	5	1141	228 2	390	78	62 4	2 93	1 69	Condensing	$24\frac{1}{2}$	Salem coal. 14,000 B.t.u. Good quality. Stoker fired.
Apr 14	6:30 a.m.	5:30 p.m.	10	2504	250 4	830	83	66 4	3.02	1 755	Condensing	26	Salem slack. 13,760 B.t.u. Full of dirt. Stoker fired.
Apr. 15.	6:30 a.m.	5:30 p.m.	10	2153	215 3	845	84 5	67 6	2 55	1 495	Condensing	$25\frac{1}{2}$	Salem lump. 14,000 B.t.u. Good quality. Hand fired.
Apr 16.	10:45 a.m.	5:30 p.m.	$5\frac{3}{4}$	1256	218 2	525	91 3	73	2 39	1 415	Condensing	$25\frac{1}{4}$	Salem lump. 14,282 B.t.u. Good quality. Hand fired.
Apr. 17.	6:30 a.m.	5:30 p.m.	10	2112	211 2	835	83 5	67	2 53	1 485	Condensing	$25\frac{1}{4}$	Salem lump. 14,000 B.t.u Good quality. Hand fired.
Apr. 18 . .	6:30 a.m.	11:30 a.m.	5	1321	264 2	390	78	62.2	3 36	2 06	Noncondensing	.	Salem run of mine. 13,843 B.t.u. Hand fired.
Apr. 18	12:30 p.m.	5:30 p.m.	5	1111	222 2	425	85	68	2 62	1 54	Condensing	$25\frac{1}{4}$	Salem run of mine. 13,843 B.t.u Hand fired.
Apr. 19	6:30 a m.	11:30 a.m.	5	1311	262 2	475	95	76	2 76	1 64	Condensing	$25\frac{1}{2}$	Salem run of mine. 13,843 B.t.u Contained dust. Hand fired.
Apr 21	6:30 a m.	11:30 a.m.	5	1115	223	375	75	60	2 97	1 719	Condensing	26	Salem run of mine. 13,843 B.t.u. Contained dust. Hand fired.
Apr. 21.	12:30 p.m.	5:30 p.m.	5	1187	237	410	82	65 6	2 89	1 68	Condensing	$25\frac{1}{4}$	Salem run of mine. 13,843 B.t.u. Contained dust. Stoker fired
Apr. 22.	6:30 a m.	5:30 p.m.	$4\frac{1}{2}$	1340	282	405	85	68	3.32	1 94	Condensing	$24\frac{1}{4}$	Salem slack. 13,760 B.t.u. Stoker fired.
Apr. 23..	6:30 a.m.	5:30 p.m.	10	2359	235 9	875	87 5	70	2 69	1 59	Condensing	$24\frac{1}{2}$	Salem slack. 13,760 B.t.u. Stoker fired.
Apr. 24	6:30 a.m.	11:30 a.m.	5	1201	240	405	81	65	2 96	1 73	Condensing	$24\frac{3}{4}$	Salem slack. 13,760 B.t.u. Stoker fired
Apr. 25	6:30 a.m.	5:30 p.m.	10	2123	212 3	835	83 5	67	2 54	1.495	Condensing	$25\frac{1}{4}$	Salem mine run. 13,843 B.t.u. Hand fired.
Apr. 28...	9:30 a.m.	5:30 p.m.	7	1874	267 7	720	102 9	82	2 60	1 56	Condensing	$24\frac{1}{4}$	Salem mine run. 13,843 B.t.u. Hand fired.
Apr. 29.	6:30 a.m.	5:30 p.m.	10	2163	216 3	900	90	72	2.40	1 42	Condensing	$26\frac{1}{2}$	Salem mine run. 13,843 B.t.u. Hand fired.
Apr. 30.	6:30 a.m.	5:30 p.m.	10	2138	213 8	865	86 5	69	2 47	1 453	Condensing	$25\frac{1}{4}$	Salem mine run. 13,843 B.t.u. Hand fired.
May 1.....	6:30 a.m.	5:30 p.m.	10	1821	182 1	835	83 5	66	2.18	1 28	Condensing	$24\frac{1}{2}$	Pocahontas run of mine. Hand fired. 13,966 B.t.u.
May 2.	6:30 a.m.	5:30 p.m.	10	1991	199 1	865	86 5	69	2 3	1 35	Condensing	$24\frac{1}{2}$	Pocahontas run of mine. Hand fired. 13,966 B.t.u.†

* Vacuum referred to 30" barometer.
** Locomobile shut down from Apr. 2 to Apr. 8 to install extended furnace and stoker. †Wet coal.

stems is shown in Fig. 10. The rings are not split but simply strung upon the rod, and form in their ensemble a labyrinth packing which appears not to suffer from the high temperatures used, and which has kept the rods in excellent shape during the months of use. The intermediate packing, between the high- and low-pressure cylinders, is so placed that nothing but steam could leak inwardly through it when the engine is run condensing.

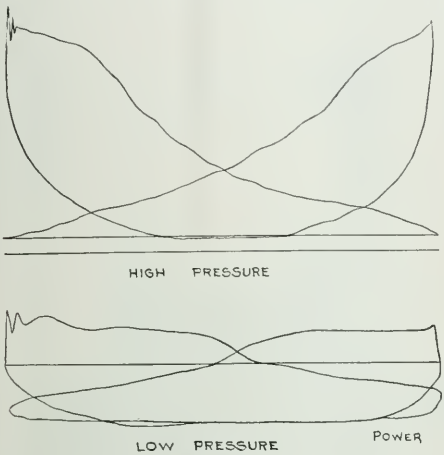


Fig. 12. Typical Diagrams from Buckeyemobile

Everything has been designed with a view to accessibility and it can be easily seen from the drawings how readily the combination of engine boiler and accessories can be taken apart.

A simple form of flywheel governor, controlling only the high-pressure valve, is used, and the results of years of Buckeye experience embodied in the handling of the engine portion. The second flywheel, is notched on the

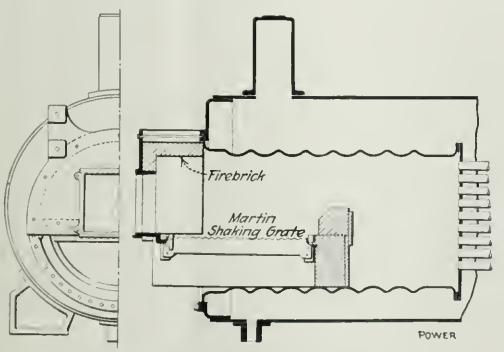


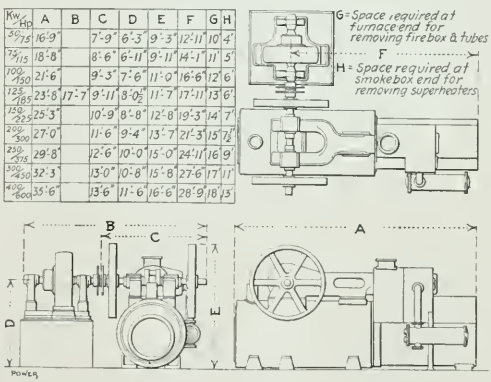
Fig. 13. Extended Firebox

inner edge, as shown in Fig. 1, and a pawl and lever *A* and *B* provided for turning the engine over by hand. Attached to the strap of the low-pressure eccentric is the rod of the boiler-feed pump, Fig. 2. A Connersville condenser (Power, Apr. 25, 1911, p. 661) is used, the rotary pump of which is driven by a belt from the main shaft. The unit under description has been under test in the Buckeye shops at Salem, Ohio, for months driving a generator to which it is direct connected through a flexible coupling. The generator is mounted upon a brick pier to bring it to the shaft level.

The photographs here reproduced have been taken while the engine was under development test and revision and do not at all bring out its possibilities with respect to appearance. In its normal condition it is neatly jacketed with sheet steel secured with polished-steel bands, lined with nonconducting material, and divested of much of the piping and apparatus incidental to its somewhat temporal and evolutionary condition.

The analysis of a test made in October is shown in Fig. 11. The engine developed an indicated horsepower on less than 9.75 lb. of steam per hour. Attention is called particularly to the flatness of the coal curve. The daily record is carefully kept and is epitomized in the following table. The unit delivers a kilowatt for about 2½ lb. of coal per hour, and an indicated horsepower-hour for some less than 1½ lb. condensing and little more than 2 lb.

Kw. / Hp.	A	B	C	D	E	F	G	H
50/75	16'-9"		7'-9"	6'-3"	9'-3"	12'-11"	10'-4"	
75/115	18'-8"		8'-6"	6'-11"	9'-11"	14'-1"	11'-5"	
100/150	21'-6"		9'-3"	7'-6"	11'-0"	16'-6"	12'-6"	
125/185	23'-8"	17'-7"	9'-11"	8'-0"	11'-7"	17'-11"	13'-6"	
150/225	25'-3"		10'-9"	8'-8"	12'-8"	19'-3"	14'-7"	
200/300	27'-0"		11'-6"	9'-4"	13'-7"	21'-3"	15'-7½"	
250/375	29'-8"		12'-6"	10'-0"	15'-0"	24'-11"	16'-9"	
300/450	32'-3"		13'-0"	10'-8"	15'-8"	27'-6"	17'-11"	
400/600	35'-6"		13'-6"	11'-6"	16'-6"	28'-9"	18'-13"	



Capacities and Dimensions of Buckeyemobiles

noncondensing. Results of special tests are given in a second table. The performance of the engine is excellent, between nine and ten pounds of steam per indicated horsepower-hour.

The analysis of the coals used in the special tests are as follows:

Kind	Salem lump	Holwick run-of-mine	Pittsburgh lump	Pocahontas
Moisture %	1 63			2 30
Volatile %	41 17	42 65	35 50	18 95
Fixed carbon %	51 10	50 22	56 10	74
Ash %	6 10	7 13	8 40	4 75
Sulphur %	3 63	1 94	2 12	0 58
B.t.u., per lb.	14,282	14,398	14 078	13,966.

Typical diagrams are shown in Fig. 12. Fig. 13 shows an extended firebox with which even better results have been attained, almost touching a pound of coal per horsepower-hour. We shall have more to say about these later tests in a future issue.

The combined electrical power output of the 7,500 central generating stations of the country aggregates 12,000,000,000 horsepower, according to one of the big electric light and power associations which has been gathering statistics on the amount of electric power generated in the United States. As an illustration of what an immense output that means, an electrical engineer says it would take 5,000,000 of the largest sized locomotives to exert this amount of power, and that it would be sufficient to propel 342,857 of the largest sized ocean steamships.—N. Y. "Tribune."

Heine Boiler Tests at Terminal Stations

SYNOPSIS—Some test figures of the performance of the boilers at the largest railway terminal station in the world. Superheated steam is used and the boiler settings are of special design.

The Grand Central Terminal of the New York Central & Hudson River R.R., recently opened to the public, is the largest terminal station of any railroad in the world, and covers an area of over seventy acres. At the north of the terminal, at Fiftieth St. and Park Ave., is situated the service plant, a building 160 ft. long by 90 ft. wide, of steel and brick construction, carried on steel columns above the tracks.

The service plant furnishes electricity for lighting, the operation of elevator and other motors, heat for all buildings within the terminal, and steam for heating of cars in the station. Fire and service pumps, freight-elevator pumps, compressors and miscellaneous pumps and boiler-plant auxiliaries are also installed.

The service station is primarily a heating plant. Steam required for heating cars within the terminal is drawn from the boilers through reducing valves. This load amounts to a large portion of the total in times of cold weather. The heating of all the various buildings within the terminal area is by hot water, heated by the exhaust steam of the various units in the power plant. At present the hot water is supplied at two pressures and temperatures in separate systems, but later when higher buildings are erected, a third system will be installed. The present low-pressure system circulates about 4500 gal. per min., and the intermediate-pressure system about 1000 gal. per min. The water is heated in three large "even-flow" exhaust-steam heaters, and is circulated by suitable motor-driven centrifugal pumps. The temperature of the water is recorded and regulated in accordance with the prevailing atmospheric conditions, thus eliminating the necessity of regulation at the radiators in any part of the system. The principal supply of exhaust steam at this time is derived from three General Electric turbines, driving 500-kw., 275-volt, direct-current generators.

The boiler equipment consists of 10 Heine boilers, six of 635 hp., and four of 550 hp. Space is reserved on the second floor, where these boilers are installed, for four additional 635-hp. boilers, and on the third floor there is space reserved for 14 boilers of a total rating equal to that on the second floor. The position of the boilers is shown in Fig. 1.

No. 2 buckwheat is fired at present by hand, but provision is made for future stokers, natural draft being provided by two steel-plate, brick-lined stacks, 17 ft. outside diameter and about 220 ft. high above the grates.

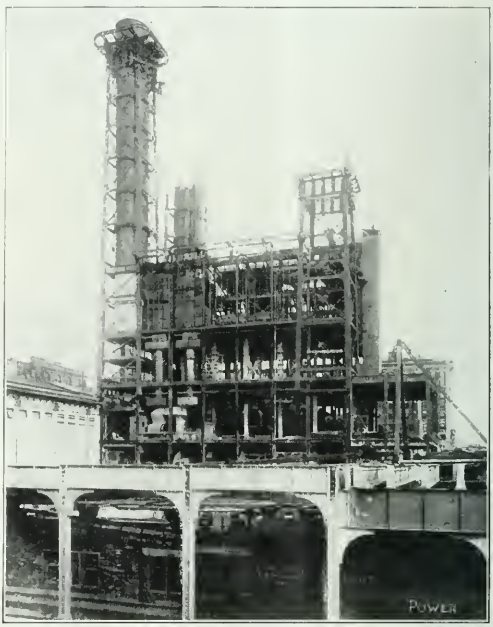


FIG. 1. HEINE BOILERS ON SECOND FLOOR OF THE GRAND CENTRAL STATION SERVICE PLANT

Forced draft when needed is furnished by two engine-driven blowers. Coal is delivered either by cars on the track level, or by trucks on the street level. It empties through chutes into a balanced skip hoist, which delivers it at the rate of 60 tons an hour to overhead storage bins of 3000 tons capacity. Ashes are removed from the first floor under the boilers.

ACCEPTANCE TEST OF A 635-HP. HEINE BOILER WITH SUPERHEATER AT GRAND CENTRAL STATION SERVICE PLANT, N. Y. CITY

Test	Oct. 30, 1912	...	Feb. 21, 1912
Square feet of shaking grates	125		125
Fuel	No. 1 Buckwheat		No. 2 Buckwheat
	N.Y.C. & H.R.R.R. Chemist as received	dry coal	Harris Laboratory as received	New York City dry coal
Coal Analysis				
Moisture	5.0		4.96	
Ash	17.93 per cent		20.92 per cent	22.02 per cent
B.t.u. per lb., coal	12,193		10,880.	11,448.
Duration of run	8.916 hr.			8.166 hr.
Total weight of coal as fired	24,640 lb.			26,075 lb.
Total weight of water fed to boiler	165,377 lb.			164,205 lb.
Coal per hour as fired	2763 lb.		(dry)	3035 lb.
Water per hour, actual conditions	18,546 lb.			26,040 lb.
Average steam pressure	179.5 gage			176 lb. gage
Temperature of feed water	62.7 deg. F.			41 deg. F.
Superheat	89.0 deg. F.			122 deg. F.
CO_2 by volume	13.80			
Hp. developed	675 hp.			755 hp.
Percentage of rating	106 per cent			119 per cent
Economic Results				
Water apparently evaporated per lb. coal, actual conditions	6.71 lb.			6.3 lb.
Equivalent evaporated from and at 212 per lb. coal as fired	8.43 lb.			8.16 lb.
Equivalent evaporated from and at 212 per lb. dry coal	8.87 lb.			8.58 lb.
Efficiency of boiler furnace and grate	70.5 per cent			72.67per cent.

In Fig. 2 is shown longitudinal and cross-sectional views of one of the 635-hp. Heine boilers with superheater. These boilers work at 180 lb. pressure, and 100 deg. superheat, and are of the two-drum type. Horizontal baffling is inserted so as to make two main passes for the gases. On the lowest row of tubes are placed a number of rows of firebrick tile, extending over the furnace, and back over the high bridge-wall, thus forming the roof of the combustion chamber. The middle baffle is located on the ninth row of tubes and consists of a special cast-iron baffle, extending from the rear water leg toward the front water leg with a sufficient opening for the passage of gases. On the top row are placed T-tiles similar to those on the bottom row. The travel of the gases is obvious. Attention is drawn to the fact that the effective path is long, and the boiler surface is compactly arranged, thus giving efficient absorption of heat in the hot gases even with the comparatively high furnace temperatures resulting from the combustion chamber formed by the tile over the furnace.

The superheater consists of two parts, one to the outer side of each drum. Each superheater is located above the water line, in a firebrick chamber formed in the setting, as shown. A flue connects the chamber directly with the furnace, and a small per cent. of the furnace gases flow up the flues and supply the heat to the superheater tubes. The hot gases make two passes over the superheater tubes, and then flow out of the superheater chamber at the end nearest the front header, so that before reaching the uptake and joining the boiler gases, they pass under the boiler drum. A damper in the superheater outlet gives complete control of the amount of gases flowing over the tubes, therefore permitting of temperature regulation and also of entirely cutting off the supply of hot gases when saturated steam is desired, or when there is no boiler load. No provision is made for flooding of the superheater as that operation is unnecessary.

The superheaters themselves are constructed of 1½-in. mild-steel, seamless-drawn tubing, bent in the form of U-elements, and expanded into box headers of a rectangular shape. Hollow stay-bolts in the headers permit of rapid and effective cleaning of soot from the superheater tubes, and handhole plates are provided for access to the tube ends. Within the headers there are two partition plates dividing the superheater box into three chambers and causing the steam to flow through the tubes in four passes.

The performance of one of these 635-hp. boilers is given by the test figures tabulated in the accompanying test tables. The tests were made with anthracite buckwheat Nos. 1 and 2 and natural draft and show efficiencies well above 70 per cent.

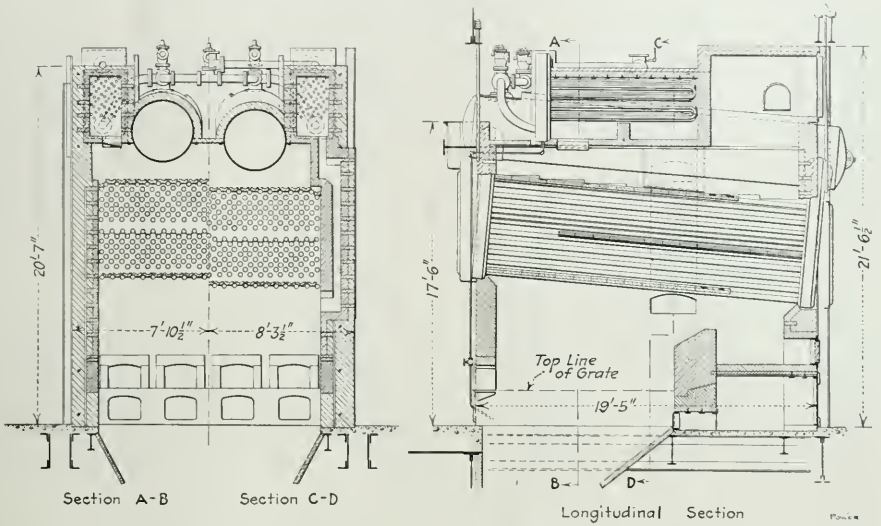


FIG. 2. END AND SIDE ELEVATION OF A 635-HP. HEINE BOILER

Interesting Repair to Elevator Plunger

An interesting mechanical job was recently done on the plunger of an Otis high-pressure plunger elevator, in the West building of the Prudential Insurance Co., Newark, N. J., by George H. Ward & Co., Brooklyn, N. Y.

The plunger had become so badly worn at the top, and the need for increased car travel so urgent, that a new plunger was needed. Because of the expense and delay which would be entailed by installing a new one, a novel repair to the old one was decided upon instead. This consisted in turning off the worn part to receive a cap which would renew the end of the plunger and increase its length, as shown in Fig. 2.

To get below the worn part of the plunger and to turn it down enough in length to receive the cap, required a portable boring bar designed especially for the job. The 7½-in. plunger was turned down to 6½ in. for a distance of 3 ft. The plunger was steel and was turned with a ¼-in. cut at a feed of $\frac{1}{8}$ in. Before turning the plunger and installing the boring bar, the car cables were put to one side of the shaft. The boring bar is shown in Fig. 1. The frame A is a hollow cylinder 6 ft. 7 in. long, bored, and with the inside face finished to act as a guide for the tool holder B. The split base clamp C was bolted to the

frame *A* with its other end slipped over the plunger to hold the latter while it was being turned. The upper end of the frame had a guide cover *D*, which served to guide the spindle *E*, which, in turn, drove the tool holder through the worm gear *F*. The spindle was made fast to

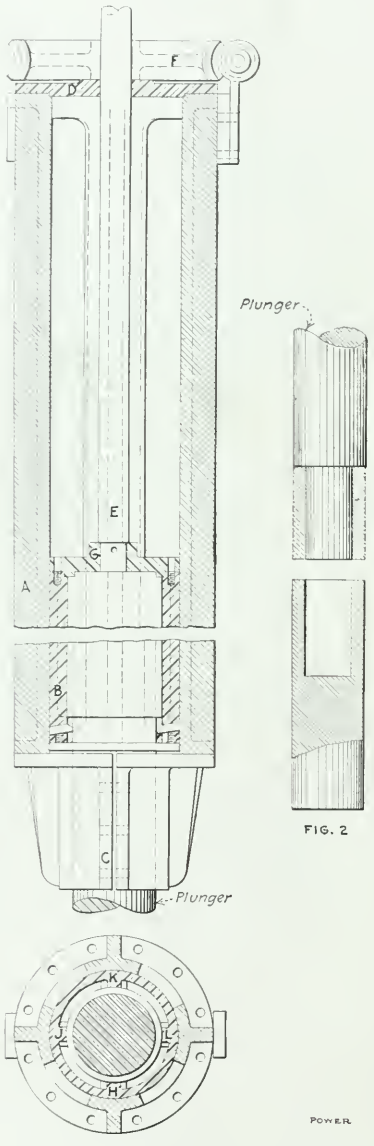


FIG. 1

FIG. 2

Portable Boring Bar for Turning Down Elevator Plungers in Position

the tool holder *B* by being keyed to a driver plate *G*, which was secured to the tool holder by ¾-in. tap bolts. The bosses through which the four tools were inserted are shown at *H*, *J*, *K* and *L*. These bosses were staggered so that one tool started a cut where another left off.

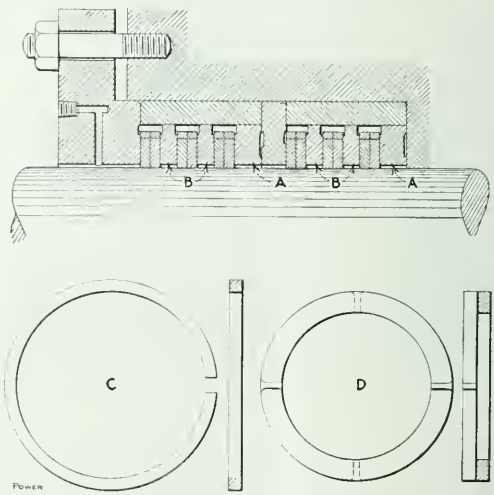
The machine was motor driven and also hand fed, as the conditions did not warrant the extra expense of power-feed mechanism.

Ward & Co. have done other interesting work on hydraulic elevators, such as reboring in position plunger cylinders of any length found in practice, without interfering with the service of adjacent elevator units.

Horton Gas-Engine Packing

A new packing for large gas engines has been designed to eliminate excessive friction and wear on the piston rod by preventing the closing of the collapsible ring under excessive pressure.

As shown herewith, the packing rings proper, *C* and *D*, are in contact with the rod. They are placed in grooves, the walls *A* and *B* of which are free to move in line with the rod and thus bind the packing rings against forcible



Rod Packing for Gas Engine

closing at the time of the highest pressure in the cylinder. In practice it is found that this side clamping of rings does not affect the sealing quality of the packing, as contact with the rod is sufficient to prevent the passage of gas, but yet so light that wear cannot be detected on the rod. All rings and corresponding parts of the packing are interchangeable.

This packing was designed and patented by James Horton, efficiency engineer of the Homestead plant of the Carnegie Steel Co., and is made by the Metallic Packing & Manufacturing Co., Elyria, Ohio.

The John Scott legacy medal has recently been awarded to the Kennicott Co. on its water weigher or measuring device. This medal was awarded by the city of Philadelphia upon recommendation of the Franklin Institute for the promotion of the mechanic arts. The Institute made a thorough and extended investigation as to the merits of the device and this award was made "in consideration of its novelty, its simplicity of design, and its accuracy as a water-measuring device."

Electrolytic Prevention of Boiler Corrosion

At the sixty-eighth ordinary meeting of the Faraday Society, Apr. 4, 1913, Prof. W. W. H. Gee, of Manchester, delivered a lecture on the subject of the prevention of corrosion by electrolytic means. The corrosion of metals can be lessened in two ways: (1) By connecting the metal to be protected to a more electropositive metal, so that a primary cell is produced; (2) by making the metal to be protected the cathode in an electrolytic cell supplied by external electrolytic pressure. An example of the first is the suspension of zinc plates in a boiler; of the second an iron plate suspended in a boiler, the suspended plate being then made the positive pole, and the boiler the negative, by means of a generator. Sir Humphrey Davy's zinc-and-iron protection for the copper sheathing of ships, and the patents of Harris and Anderson, in which aluminum alloys are used for the prevention of the corrosion of boiler tubes, are also examples of class (1).

The efficiency of the cell for protection will depend on the current density of the cathode, and this will be controlled by the resistance of the cell and the effective voltage. In the use of zinc in boilers a knowledge of the electrolytic resistance of the boiler waters and the effective voltage from 300 to 400 deg. F. is desirable. For this information there is great need of experimental data. The amount of zinc used in some marine boilers amounts to 400 to 600 lb. per annum, and the current may be 17 to 25 amp. It is clear that using currents of this size, it is cheaper to generate the electric current by mechanical means (generator) than by chemical means (zinc plates).

The use of an external source of power and iron cathodes (certain modifications of which are covered by patent) not only prevents corrosion, but is said also to remove and to prevent boiler scale. Experiments carried on in the Manchester School of Technology have shown that the current densities necessary to prevent the corrosion of iron, copper and similar metals by fresh and salt water are of low value, and hence the cost of the electric energy required is a small matter. The chief cost will be the renewal of electrodes. Harris and Anderson have also applied electric currents to the prevention of corrosion in condensers. They find a condenser with a cooling surface of 1025 sq.ft. requires only 2 amp. at 2 volts pressure while the anodes cost £31$_4$ ($15.80) per 1000 sq.ft. of condenser surface per annum. Electric currents may also be used in chemical works to prevent the corrosion of metallic screens and vessels by acid liquids.

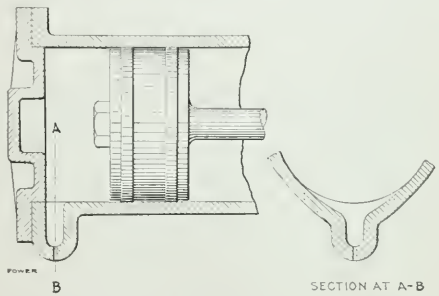
[On the basis of power at 0.6c. per kw.-hr., the current for condenser protection would cost only 21.02c. per year. That such an amount of current would use up almost $16 worth of electrodes seems absurd, but these are the figures given by Mr. Gee. There must be a tremendous amount of local action in the anodes he reported on.—Editor.]

To Avoid Cylinder Condensation

When the steam enters the cylinder of an engine it comes into contact with walls and surfaces which have just been exposed to the comparatively cool exhaust steam, and chilled by the evaporation of the water which was deposited upon them. The incoming steam condenses upon the surfaces with the result that, in an ordinary unjacketed engine with a ratio of expansion of four or five, there is about 20 per cent. by weight of water in the cylinder contents at the point of cutoff. Some of this water is reëvaporated during the expansion stroke as the pressure lowers, but most of it is reëvaporated after the exhaust valve opens, the reëvaporation being done at the expense of heat taken from the cylinder walls, which cools them for the next incoming charge.

H. Bollinckx, the well known Belgian engine builder, suggests the forming of a small pocket in the clearance of the cylinder, as shown in the accompanying sketch, into which this water may drain, and from which it may be blown out through the small hole shown.

In a 20x32-in. cylinder, cutting off at $^1/_4$ stroke, there



Pocket to Entrap Cylinder Condensation

would be, with 20 per cent. initial condensation, about 3 cu.in. of water in the cylinder at the point of cutoff. It is not improbable that a considerable quantity of this would find its way into the little well during the period of admission and expansion, and would have escaped by the time the exhaust valve opened, so that it would not chill the surfaces by its reëvaporation. Engineers have a propensity to run with the drip valves cracked a bit open. Perhaps their observation has suggested a possible advantage in this direction.

No patent has been taken out on the idea and anyone desiring to make use of it is at liberty to do so.

Large English Condensing Plant

Another large surface-condensing plant, duplicating one already installed, has been ordered for the Leeds Corporation Electricity Works, Leeds, England, from the Mirrlees Watson Co., Ltd., Glasgow, Scotland. The plant will be capable of handling 130,000 lb. of steam per hour, and will be connected to a turbo-alternator, which will be built by Willans & Robinson, Rugby, England. The condenser is of a very special design on account of the dirty water obtained for condensing purposes from the river Aire. This water contains a large amount of woolen material, which, along with mud, soon clogs up the ordinary type of condenser. The condenser is designed so that all the tubes can be cleaned out while the plant is in operation. The flow of the cooling water can be reversed without interfering with the running of the plant. The condenser is of the vertical type and has 24,800 sq.ft. of cooling surface. Its total height is 28 ft. and weight 85 tons.

ELECTRICAL DEPARTMENT

Care and Operation of Commutators*

By H. S. Page†

The successful and economical operation of a direct-current plant is largely dependent upon the proper maintenance of commutators and brushes. Numerous improvements in the design of direct-current apparatus are constantly leading to higher speeds and to greater capacity of units. This, in turn, necessitates not only better commutators, brushes and brush rigging, but a more definite understanding, on the part of operating engineers,

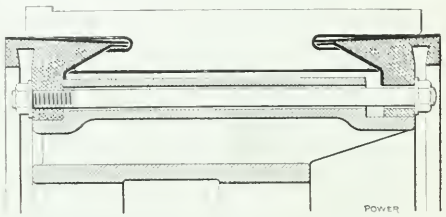


Fig. 1. Arch-Bound Type of Commutator

with regard to the proper care to be exercised in order to minimize the maintenance expense.

The primary requirement in the construction of a commutator is that the mica and copper segments shall be held firmly in a compact arch and be so supported that there is a minimum tendency toward distortion, resulting from centrifugal stresses or from alternate heating and cooling. This is accomplished generally by two methods: In the first (Fig. 1), the segments are built up in a cylindrical arch and are held in place by two wedge-shaped clamping rings, secured by bolts and supported on a shell or spider. Such a commutator has an actual clearance between the shell and segments and is known as the arch-bound type.

In the second (Fig. 2), the segments are held in place by clamping rings bolted together, and are also seated on the body of the shell. This is known as the body-bound type.

A few commutators, designed for exceptionally high speeds, are held together entirely by strings of high-grade steel, shrunk upon the outside at a tension greatly in excess of the centrifugal stresses encountered at maximum speed.

It has been a common practice, especially on new commutators of the arch-bound and body-bound types, to tighten the bolts at the least indication of surface roughening. The necessity of tightening the clamping-ring bolts has been due to the whole structure loosening during the so called process of "seasoning." Commutators of recent manufacture, however, having an improved grade of mica, together with better proportioned rings and bolts, require little or no tightening; in fact, such a practice may be very detrimental as the clamping ring may be drawn out of shape or dished, and the copper segments forced out of position. This action will not take place uniformly around the periphery and the commutator will accordingly have displaced bars and show all the indications of being loose.

Too much importance cannot be placed upon the proper staggering of brushes in order to minimize, as far as possible, the wearing of grooves in commutators. With a generator, in addition to wear resulting from mechanical abrasion, there is an electrolytic disintegration of the copper segments passing under the positive brushes, and of the negative brushes delivering current to the commutator. Hence, copper wears away more rapidly under the positive brushes than under the negative.

The proper brush position must be considered for each individual machine and it is the practice of manufacturers to either locate the correct running position permanently or where this is not practical, to furnish instructions covering the proper setting of the brushes. Brush position not only affects commutation, but is a factor in determining the voltage or speed characteristics. However, the brushes should be set for best commutation and

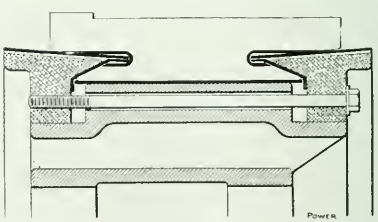


Fig. 2. Body-Bound Type of Commutator

any adjustment for voltage or other characteristics obtained by other means. The brushes of noncommutating-pole machines are generally given a definite "lead" from the neutral position, whereas those on commutating-pole machines are run on the neutral point.

During the past few years great strides have been made toward producing special grades of brushes for various conditions of service. It is impossible to make fixed rules governing the selection of brushes best suited for all cases, but a few comments regarding the characteristics of various grades of brushes, with some of their principal applications, may be of assistance to operators.

Compared with carbon, graphite brushes have a higher coefficient of friction, lower contact resistance, higher current capacity, less tendency to chatter, greater lubricating properties and ability to give better commutator polish. On account of their low contact resistance, graphite brushes can be used on very few high-voltage machines (500 volts and over) without producing sparking, while on nearly all low-voltage apparatus they usually give excellent results. It should be noted that graphite brushes

†Direct-Current Engineering Department, General Electric Co.

*From an article in the May issue of the "General Electric Review."

have very little abrasive material in their composition, hence they will not wear the mica rapidly enough to keep it even with the surface of the copper. For this reason it is common to slot the side mica to a depth of $\frac{1}{32}$ in. to $\frac{1}{16}$ in. below the surface, wherever graphite brushes are used. As an alternative, some dry-carbon brushes may be used to keep the mica worn down, the remaining graphite brushes acting as lubricators. Successful results have also been obtained by using graphite brushes with a small percentage of abrasive material in their composition, which serves to wear the mica more uniformly with the wear of the copper.

A given grade of brush will give the best results only when fitted in a properly designed brush-holder and it should be borne in mind that no brush-holder suitable for universal application has yet been made. The question of brush-holders is important as it is necessary to provide for free radial movement and at the same time arrange the brush supports so that there is a minimum tendency to bind or chatter. Frequently, a change from carbon to graphite brushes necessitates new brush-holders so arranged that the brushes will ride at a different angle and have an entirely different scheme of applying the pressure.

Machines fitted with graphite brushes have been known to develop severe sparking after operating for some time with excellent commutation. In such cases, investigation usually shows that as a result of the commutator polish gradually improving, the brush friction is reduced with a consequent change in the position which the brushes take in the holders. This in turn results in a tendency of the brush to ride on either its heel or toe, raising the opposite edge a very small amount away from the commutator; a short arc is set up under that portion of the brush, which is raised slightly from the commutator, and the heated particles are thrown out in the form of long yellow sparks. An increased brush pressure will frequently cure such trouble.

Cleanliness is always essential to best operating conditions, but, in cases where the atmosphere is filled with foreign substances which it is impossible to eliminate, the nature of the substance must be considered, and such treatment applied as will minimize its detrimental effects. For example, the same brush equipment or treatment might not be applicable to two duplicate machines, one installed in comparatively clean surroundings, such as the average railway substation, and the other at a coal mine or cement mill, where the air is filled with foreign matter. In the one case, brushes with slight lubrication would probably give the best results, while in the other, the use of any lubricant would have a tendency to collect the dust, and, in the event of such foreign matter being of a conducting or abrasive nature, poor commutation and destruction of both brush and commutator surfaces would undoubtedly follow. Under the latter condition dry-carbon brushes would probably be satisfactory if the machine were of a slow-speed type, but if operated at high speed, chattering might result, and about the only alternative would be the use of some form of graphite brushes, if commutation permits.

Successful methods of keeping machines clean may be outlined as follows: In a fairly clean station, with machines using carbon brushes, unless proper care is exercised an accumulation of foreign matter may appear on the commutator surface. This can be prevented by lubricating sparingly with a good grade of light engine oil and wiping off with a clean cloth. In steel mills, mines, etc., where the atmosphere may be full of conducting grit and the machines have graphite brushes, the commutators should be wiped frequently with a dry cloth and any accumulation of dirt removed from the brush rigging, as this is likely to fall on the commutators and be ground into the brushes. In such plants, screens should be placed so as to protect the apparatus from drafts and soot-laden air. For wiping commutators, such material as heavy canvas should be used, as the lint from waste or cheese cloth catches under the brushes and causes trouble.

Whenever brushes are replaced, the new ones should be carefully fitted to the commutator with sandpaper. To fit a set of brushes, the sandpaper should always be drawn in one direction, preferably the direction of rotation.

When the brushes wear down, sometimes the copper plating comes in contact with the commutator, causing burning. A new set should always be examined and any excess plating which may cover the wearing length should be removed. The purpose of the plating is to give better contact between the carbon and the pigtail terminal and to permit of a soldered connection, but it frequently extends too far toward the contact surface of the brush.

Brush pressure should be studied by the operating engineer to determine the degree which will give minimum friction and at the same time be sufficient to permit the brushes to ride properly on the commutator. Too high a pressure will result in excessive heating and sometimes causes the brushes to bind in the holders. Too little pressure will permit the brushes to change their position in the holders and chatter, thus causing sparking.

Oil is detrimental to mica and its accumulation on any part of the commutator should not be tolerated.

Numerous methods have been devised for truing commutators which have become badly grooved, rough or eccentric, and brief comments will be made on those most frequently employed.

Turning Tool

This consists of a simple tool post, for holding the cutting tool, mounted on suitable ways and fitted with a cross-feed screw. The tool must be mounted very rigidly to prevent chattering and a cutting speed of about 550 ft. per min. has been found best. Unless such a tool is operated by an expert, too much of the surface of the commutator may be turned off. Another objectionable feature is that there are but few commutators whose normal peripheral speed is as low as the tool-cutting speed required, and, therefore, the others will not have the same throw as will occur when under service conditions. Occasionally, a commutator is ground with a stone clamped in the tool post, but such a method is very slow and the tool is seldom sufficiently rigid to entirely remove "flats."

Sandpapering Block

This is a simple device consisting of sandpaper held in a wooden block, having approximately the same curvature as the commutator, and applied by hand or by means of a lever using the machine base as a fulcrum. Such a device is liable to aggravate flats and removes nearly as much material from between ridges as from their tops.

Grinding Tool

The grinding is accomplished by an excellent device, consisting of a rotating grinding wheel, so arranged that

it can be fed back and forth by means of a lead screw. The grinder must be rigidly supported to prevent vibration. The advantages of such a tool are that the minimum copper is removed, a perfect cylindrical surface is obtained, and the work may be done with the machine at full speed, where the commutator will have its normal "throw" or "swing," and will take its actual running position in the bearings. In cases of emergency, commutators have been ground with the machines actually operating on the line. The success of such a tool depends upon its being rigidly supported and having closely fitting bearings, so that there is no vibration of the grinding wheel. The latter must be of such composition as will not wear away too rapidly or clog with copper.

Whenever any truing device is being used, all windings should be protected from copper dust, and the brushes should be raised to prevent their being coated with copper on the contact surfaces. Such protection is further assured by the use of a grinding tool provided with a wheel shroud and exhauster with bag attachment for collecting the dust.

A light application of fine sandpaper held in the hand will give a much improved surface after turning or grinding. Before bringing the machine up to voltage the segment insulation must be gone over carefully and any evidence of copper bridges from bar to bar removed. Slotted commutators should have the slots cleaned out with a hacksaw blade and the edges slightly beveled or rounded. The machine should then be blown out and all accessible parts cleaned thoroughly, followed by a final wiping of the holders and brushes, before being put in service.

In the long run, close attention to everyday duties counts more than anything else toward keeping the electrical apparatus of a plant in prime condition. If the brushes chatter and spark it is probably due to high mica, rough commutator or incorrect angle of the brushes. When commutators are true and smooth, but show black bars, this is an indication of poorly soldered joints in the armature winding or equalizer connections, or possibly an insufficient number of equalizer rings.

CORRESPONDENCE

Recharging Dry Batteries

In answer to Mr. King's letter in the Apr. 8 issue, stating that his dry batteries did not respond to the treatment prescribed by Mr. McGerry, I think the latter is mistaken in claiming that dry batteries can be recharged with current from an outside source. He says to melt a hole in the wax and let them be submerged in water for a few minutes then seal them up again before charging. The result which he gets is not due to the charging process described, but is due wholly to letting them stand in water. If he will take an old battery and dissect it, he will find next to the zinc that there are several layers of blotting paper, then the contents of the battery, which is composed of some absorbent material, such as carbon, manganese dioxide or graphite, with the carbon rod in the center. This has the binding post attached when the batteries are assembled. The mixture used for filling is thoroughly saturated with sal ammoniac or other chemicals, after which the zinc tube is sealed with pitch or wax.

The battery loses its strength, due to the gradual drying out of the solution used to moisten the contents, and can sometimes be revived by melting the wax and saturating the contents with water, sal ammoniac or salt water, then resealing. Provided the zinc is not corroded too badly the batteries will last some time and show very good results.

Another way is to take off the pasteboard cover and puncture the zinc with six or eight holes then set the battery in a can of water and let it remain there for door-bell or telephone service, care being taken to keep the cans full of water and see that they do not touch.

LEON L. POLLARD.

Fairfield, Maine.

Oil Throwing

When out on trouble work some time ago I came across two unusual cases of oil throwing which may be of interest to readers of POWER.

The first occurred in connection with a 500-kw. direct-current traction generator which was coupled direct to a high-speed, vertical, triple-expansion engine running at 150 lb. pressure and high superheat with the usual pressure-lubricating system.

Oil was found to accumulate at the back of the commutator and when the set was running this oil was thrown about. It was easily proved that the oil did not come from the dynamo bearing and a flywheel between the engine and the dynamo precluded any possibility of oil coming from that source.

The trouble was finally traced to the stuffing-box on the high-pressure cylinder. A certain amount of oil leaked through here and this became vaporized and was carried by the draft through the armature spider and condensed on the comparatively cool surfaces behind the commutator. A small amount of steam and water also leaked through from the high-pressure cylinder and this became mixed with the oil and thus helped in the condensation. The trouble was overcome by completely inclosing the piston rod with sheet metal.

The other trouble occurred on the middle bearing of a 500-kw. motor-generator set.

The oil in this case leaked out of the ends of the bearing just as if it were overfilled and the drops were carried by windage onto the stator windings of the motor. It was again proved that the oil was not creeping along the shaft. Various kinds of oil were tried without lessening the trouble, which was eventually found to be caused by the oil ring throwing oil onto the inside of the bearing cap, whence it ran down to the joint between the top and bottom halves of the bearing shell and was then carried along the joint by a kind of pumping action due to vibration.

It was not found possible to eliminate all of the vibration and the remedy applied was the fitting of a sheet-metal lining to the inside of the bearing cap and extending this to overlap the joint to prevent the oil reaching it.

The remedy is simple and quite effective. I have since seen it applied in several instances where all attempts at improving the lining up of machines had failed.

Schenectady, N. Y. N. M. HILL.

GAS POWER DEPARTMENT

Gas-Engine Sounds

By A. L. Brennan, Jr.

Practically all contingencies which arise during the operation of a gas engine are manifest in one way or another by some form of sound, and if one will pay strict attention to these noises and note their indications he will become conversant with an internal-combustion motor in a way that will prove of great benefit. Gas-engine sounds can be divided into two general groups, as follows:

Group 1. The sounds produced by the normal operation of the motor; these include the roar at carburetor, the click of valves, roar of gears and other rhythmic sounds, which are easily recognized.

Group 2. Unusual noises, which are in many cases symptons of trouble, may be subdivided into five parts:

1. Knocking—mechanical or functional.
2. Pounding—mechanical.
3. Squeaking—lack of efficient lubrication.
4. Hissing or puffing—gas under pressure escaping.
5. Numerous irregular puffs and pops.

Knocking is invariably produced within the cylinder and acquires the form of a regular and continuous tapping which is quite distinct and easily recognized as not being a sound generated by normal operation. Experience in operating gas engines will be of great help in determining this special sound, but not altogether necessary as it is one of the easiest to recognize.

Functional knocking can be attributed to a faulty mixture, early ignition or preignition from incandescent carbon deposits. If due to a faulty mixture, this will invariably be found too rich, and when ignited it burns either too quickly or too slowly, usually the latter. In some cases this form of knocking results from allowing the engine too much gas of a correctly proportioned mixture, thus interfering with ready combustion and partly preventing the cylinders from clearing themselves of the burnt gas; this is commonly referred to as "choking up."

When the spark is responsible for knocking, it is invariably because of too early ignition, the explosion taking place before the compression stroke is completed, thus a heavy rapid force is exerted on the piston before dead center has been passed. Incandescent carbon deposits often bring about a similar occurrence by igniting the fresh gas as it is undergoing compression; the symptoms in this case are almost identical with those of the former. Hence, if a knock becomes apparent within the cylinder, the trouble usually may be remedied by retarding the spark, reducing the amount of gas allowed the engine or making the mixture leaner. In regard to over-rich mixtures there are several symptoms, apart from knocking, which indicate this condition, namely, the engine firing regularly but weak, and other symptoms which will be learned with slight experience.

If, on retarding the spark, changing the quality of the mixture and the amount thereof, the knocking does not abate, it is evidently due to carbon deposits. Sometimes carbon deposits have no effect on a motor at normal speed, but when operating at high speeds, which tends toward overheating, especially in cases where considerable gas is allowed and the spark is retarded, the carbon deposits will become incandescent and preignition will result.

The knocking attributed to the foregoing causes is in some instances so severe that they resemble a heavy pound, but varying to a considerable extent, according to the type of motor; in small high-speed engines the sound is slightly sharper and more distinct than in heavy slow-speed motors.

Other knocks peculiar to the cylinder can be attributed to loose or worn bearings, or to any parts of the piston, rings, wristpin, connecting-rod, or cylinder having mechanical lag or play. Except in extreme cases, however, knocking produced by any of these causes will not be so severe as that previously mentioned. To an inexperienced operator, knocks which are not directly allied to the cylinder will seem to originate at that point. Troubles of this order can be traced by placing one end of a hammer or other tool against the motor and resting an ear on the other end.

Loose or badly worn crankshaft bearings will cause heavy pounding.

Squeaking is more often a sign of inefficient lubrication than insufficient lubrication, as is generally supposed. If neglected it will eventually lead to overheating, rapid wear and probably knocking.

Hissing and puffing sounds which in some cases resemble wheezing often may be traced to a faulty piston or to a cylinder worn oval. Poor lubrication in the cylinder will bring about rapid wear of the rubbing surfaces resulting in this condition, which indicates the loss of gas while under compression and during the power stroke. This, of course, diminishes the efficiency of the motor. Any misalignment of the piston pin, connecting-rod or crank throw will induce this kind of wear in the cylinders.

Other hissing sounds can be traced to faulty gaskets, loose spark plugs or igniters, inlet or exhaust valves not seating properly, loose exhaust manifold or unions on the exhaust pipe. These are not all the unusual sounds and their indications found in a gas engine, but are sufficient to help the average operator in speedily locating trouble.

Having considered sounds in a general way, means of preventing these troubles will now be taken up. In many instances the cause for a mechanical knock is the same as that which produces a functional knock, namely, faulty lubrication, by allowing wear in the first place, and carbon deposits in the second. The prevention is to use suitable quantities of cylinder oil of good quality, high flash point and proper viscosity. It must be born in mind that this condition is only approximated, that is, no matter how careful an operator is in maintaining a correctly proportioned mixture in conjunction with well regulated lubrication, carbon deposits will be constantly forming,

but they will be so slight as to prove in no way detrimental.

On some motors the oil supplied for lubrication between the cylinder walls and piston is also called upon to lubricate the wristpin. Therefore, an oil that does not undergo much change when subjected to the high temperatures of the cylinder must be used. Oil that is easily burned or which gums up will not perform this function well and it will be but a comparatively short time when the piston rings will become so gummed up as to render the lubrication of the wristpin inadequate, resulting in wear and finally a knock, which will rapidly grow worse.

Motors employing the splash-feed system of lubrication are prone to carbon deposits, due to excess oil being thrown up at times; this, in turn, is usually traceable to an over supply in the crank case. This is easily avoided by adding small amounts of oil to the crank-case supply at frequent intervals instead of greater amounts at longer intervals.

Excessive lubrication of good oil is quite as harmful in the long run as poorer oils fed in about the correct proportions. Viscosity has a great deal to do with proper oiling or, in lubricating other parts, with various mediums, such as hard grease, graphite, etc. Therefore, although an oil might have a high flash point, it may still be unsuitable for cylinder lubrication.

Any mechanical features which show signs of looseness should receive prompt attention. By looking after troubles of this nature at once little difficulty will be experienced in maintaining efficient operation.

Obviously, mechanical depreciation of a mechanism cannot be altogether overcome. This holds true especially of internal-combustion engines, due to the fact that they operate under variable conditions, which, in some cases, are very exacting. It is well to remember, however, that a gas engine will generally give warning of approaching trouble in time to prevent any particular harm.

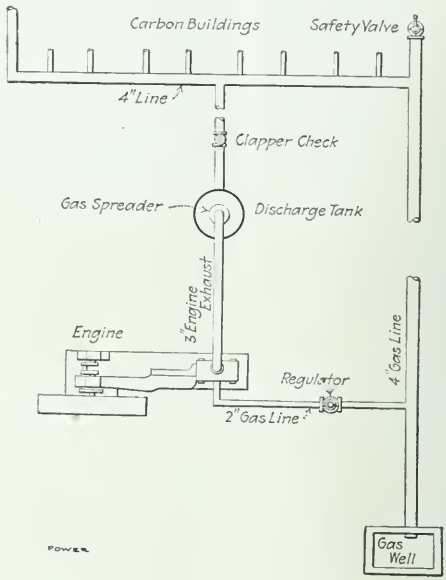
Utilizing Initial Gas Pressure

A somewhat novel method of power generation is employed at the Wilsonburg, W. Va., plant of the Union Gas & Carbon Co., manufacturer of carbon black. This product is the hydrocarbon extracted from the flame of natural gas by impinging it on a smooth surface and then removing the deposit by means of steel scrapers. The carbon black is used extensively in the manufacture of printing ink and paints.

The natural gas is supplied from a well 3000 ft. deep and at a pressure of 950 lb. Formerly this was led through a 4-in. main direct to the carbon buildings and the power necessary for driving the scrapers, etc., was obtained from a steam boiler and engine.

The management, however, conceived the idea of utilizing the initial pressure of the gas by passing it through the cylinders of the steam engine, the latter serving in the capacity of a reducing valve and, at the same time, doing away with the use of steam. Accordingly, the piping was arranged as shown in the sketch, a 2-in. branch being taken off the 4-in. gas main and led through a regulating valve to the engine. The exhaust is led into a discharge tank, a spreader being provided at the end of the exhaust pipe. From the discharge tank the gas passes through a 3-in. main to a clapper check valve, which works simultaneously with each chug of the exhaust and allows the gas to feed into the carbon buildings with constant regularity.

By using gas in place of steam in this manner, the engine is said to respond quicker and more uniformly. It also, not only provides free power, but reduces the labor by one man.



Layout of Piping

CORRESPONDENCE

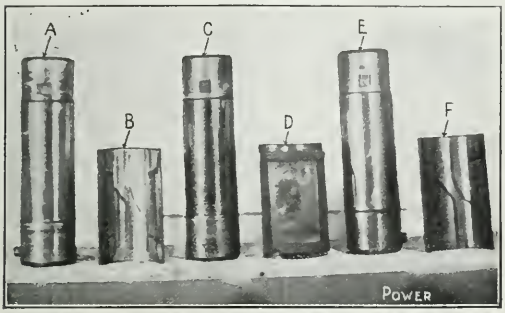
Results of Good Lubrication

In our power plant, consisting of four vertical Westinghouse gas engines, we recently overhauled two, cleaning the pistons and putting in new rings, also renewing the piston pins, lower crosshead brasses, wedges and wedge bolts.

The engines have been in service in an office building eleven years where power is required day and night. These two engines have had new piston rings four times during that period; but this was the first time that any of the pins or brasses have been renewed. When the pins and brasses were taken out it was found that they would have been good for a number of years more service. The pins showed hardly any wear, the lower brasses showed only slight wear, while the top brasses were apparently as good as new and were put back again. The only parts showing wear were the threads on the wedge bolts and in the wedges, some being worn nearly to the point of stripping; but as they receive the hardest strain of any of the parts it was expected that they would be badly worn.

The accompanying illustration shows a set of pins and brasses from one of the engines. The first *A* shows the working side of one of the piston pins; *B* is one of the

lower crosshead brasses still containing good, deep oil grooves; *C* is a side view of a pin, the working side to the left and the idle or top side on the right; *D* is a bottom view of one of the brasses, showing very little wear of the wedge, also showing that the wedge was only about half way up; *E* shows the idle side of a pin; and, *F* one of the brasses just as it was taken out of the engine



Bearings and Pins after Removal

without being cleaned, showing the oil grooves nearly filled with carbon, which is common in gas-engine bearings.

We have credited the good wearing qualities of our bearings to our careful and special method of lubrication.

L. M. Johnson.

Emsworth, Penn.

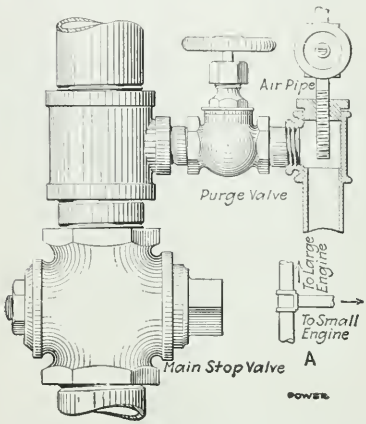
Difficulty in Starting a Gas Engine

Some time ago I had charge of a plant containing two gas engines running on suction-producer gas. One was a 16-in., two-cylinder, vertical running at 250 r.p.m., and the other a 14-in., single-cylinder, horizontal machine running at 180 r.p.m. The latter was run morning and evening for about two hours each when the load was heavy. The two engines ran off the one producer, the connections being as shown at *A* in the sketch.

Upon starting the smaller engine the larger would not let it get the gas, since it ran faster, was larger and was situated nearer the producer. As soon as the small engine was given a few shots of air to get it in motion and the gas valve was opened, the air would rush in, caused by the suction of the other engine, and draw the gas away from it. I tried getting the small engine in motion with compressed air and have someone throw in the friction clutch on the lineshaft to pull it up to speed; then open the gas valve. Then the engine would suck the gas until it came to the cylinder, when it would start to take explosions and commence working in parallel with the other engine. The small engine was driving a lineshaft on the other side of the yard from the large engine, the two shafts being connected by a long belt with about 75 ft. between centers.

This proved to be an inefficient method of starting, however, as it not only pulled down the speed of the shaft, but burned the hard-wood blocks in the friction clutch and caused no end of trouble. After trying different methods, I finally succeeded in making a device which proved successful and which may help someone else who has two engines running under such conditions.

There was a 1¼-in. nipple and valve in the gas pipe just above the main stop valve to be used as a purge pipe. Into this valve I screwed a nipple and tee. I then put a bushing on the one side of the tee and a 1¼-in. nipple 6 in. long on the other side. Into the bushing I screwed



Scheme for Sucking Gas to Engine

a ⅜-in. pipe so that its lower end extended below the center of the tee, the other end being connected with the air tank.

For starting I opened the valve on the purge pipe and then opened the small valve on the air pipe, this acted as a siphon and drew the gas to the engine. After giving the engine a few shots of air at 150 lb. to get it in motion, I opened the gas valve to the engine, closed the 1¼-in. valve and shut off the air. The engine would then continue to draw the gas.

Harry Westwood.

Stratford, Ont.

Binders for Fuel Briquettes

Experience in European countries and investigations made at the fuel-testing plant of the United States Geological Survey at St. Louis, and later by the Bureau of Mines at Pittsburg, have shown that lignite may be successfully briquetted without the use of any additional binding material, and that the most satisfactory binders for anthracite, semi-anthracite, bituminous and subbituminous coals are coal-tar pitch, gas-tar pitch and asphaltic pitch.

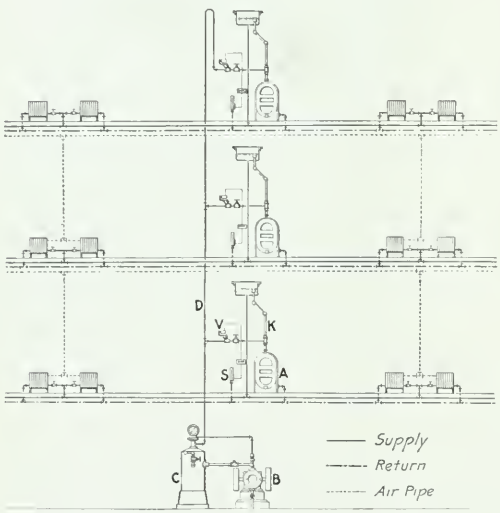
Of the 19 briquetting plants in commercial operation in the United States during 1912, 10 used as a binder coal-tar pitch, or mixtures in which it is the chief ingredient; one plant used asphaltic pitch, two used water-gas pitch; four used mixed binders whose composition is not made public, and two (one operating on peat and the other on carbon residue) used no binder.

Inorganic binders, such as cement, have not given satisfactory results, for, although they may form efficient binders they have the serious objection of increasing the ash and adding nothing to the combustible elements of the fuel.

HEATING AND VENTILATION

Compressed Air to Circulate Hot Water

In the isue of Apr. 15, a short note concerning the introduction of compressed air into the riser of a hot-water heating system was published. Since that date additional information has come to hand. An illustration of the system designed by Herman Kraus, engineer of the German Musuem in Munich, is shown herewith. The compressed air is introduced into a riser leading directly from the heater, or hot-water boiler to the expansion tank, where the air escapes and the water is returned through the radiators to the heaters. The supply of air may be controlled by the outside temperature or, as shown



KRAUS HOT-WATER SYSTEM USING COMPRESSED AIR

in the drawing, by the temperature of the return. A thermostat is connected with the return and controls a pressure-reducing valve on the air supply.

The compressed air is supplied by an electrically-driven compressor which is automatically controlled according to the presure in the air tank. From the tank, the air passes through the reducing valve and enters the riser through a specially designed nozzle.

In the sketch *A* represents the hot-water heater, *B* the air compressor, *C* the air tank, *D* the air-pressure piping, *V* the reducing valve, and *S* the thermostat. It may be noticed that an expansion tank *E*, and a hot-water heater are shown on each floor. From each expansion tank there is a connection to atmosphere so that air may escape without having the oportunity to enter the radiators and interfere with the operation.

In the state sanitarium at Hütteldorf, Vienna, ten large buildings are equipped with this system. The installations were made five years ago, and according to reports have given excellent satisfaction. Some of the advantages claimed by the inventor are adjustment of the rate of flow according to the outside temperature or to the temperature of the return, the possibility of obtaining the necessary amount of compressed air for a full day inside of one or two hours, central regulation, no possibility of overheating the water in the system and the use of pipes of small diameter.

Any hot-water heating system can be fitted up with the air equipment at small cost. The system is recommended especially for green houses where uniform and high temperature is essential.

Hot-Water Direct-Heating Charts

BY FRANK B. GILBERT, JR.

Various methods are used in computing the amount of radiation required for heating, although the heat unit is the most satisfactory basis. The relations commonly used are expressed by the formula

$$Sq.ft.\ rad. = \frac{E \times C \times D}{F}$$

where

E = Square feet of exposed building surface;
C = Coefficient of heat transmission = B.t.u. transmitted per hr. per sq.ft. per deg. difference in temperature;
D = Difference in temperature;
F = Radiator factor = B.t.u. radiated per hr. per sq.ft. radiator surface.

Application of the formula is simplified by using the accompanying charts, the design of which includes the following values of the coefficient of transmission C.

	C
Skylight (single glass)	1 12
Slate roof	1 10
Window (single glass)	1 00
Shingle roof	0 90
Corrugated iron wall	0 84
4-in. brick wall	0 68
Skylight (double glass)	0 62
8-in. brick wall	0 46
Wooden door	0 42
12-in. brick wall	0 33
Wooden wall	0 28
Wood and composition roof	0 28
16-in. brick wall	0 27
20-in. brick wall	0 23
24-in. brick wall	0 20
Wooden ceiling	0 104
Wooden floor	0 08

The value of F is taken at 150, which holds for the usual hot-water system operating under ordinary conditions. East, west and north exposed surfaces are considered as losing 10, 20 and 30 per cent., respectively, more heat than a wall of south exposure.

Illustrations of the use of the charts are shown by the dotted line on which arrows indicate the order in which the several sets of curves are to be taken. In Fig. 1 the problem illustrated by the dotted line is to determine the

amount of radiation necessary to supply heat radiated to out-of-doors by 3000 sq.ft. of 12-in. brick wall with a west exposure and a temperature difference of 80 deg.

Starting at the 3000 division of the scale for square feet of exposed building surface located along the right-hand edge of the chart, the line of reading would follow to the left until intersecting the line representing a 12-in. brick wall. From this point of intersection follow vertically to the line of 80 deg. temperature difference, thence horizontally to the line indicating west exposure and vertically to the scale of required radiation, which gives a reading of 630 sq.ft.

The proportioning of the amount of radiation necessary to heat incoming air is largely a matter of experience in assuming the number of times per hour the total air contents of the building will be changed. This factor varies for different types of construction and depends also on the probable frequency with which doors and windows will be opened. For an average value, one air change per hour for ordinary factory buildings is consistent. For residences, two air changes per hour on the first floor, one and one-half on intermediate floors, and one on the top floor may be used.

Fig. 2 gives graphical solutions to problems involving

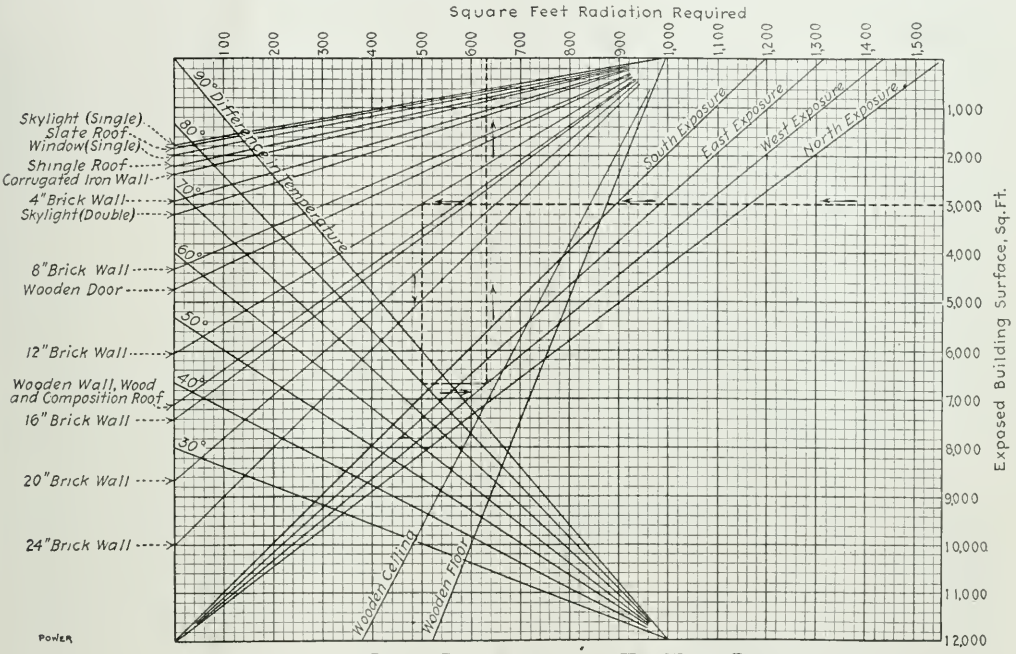


FIG. 1. CHART FOR DIRECT DETERMINATION OF HOT-WATER RADIATION

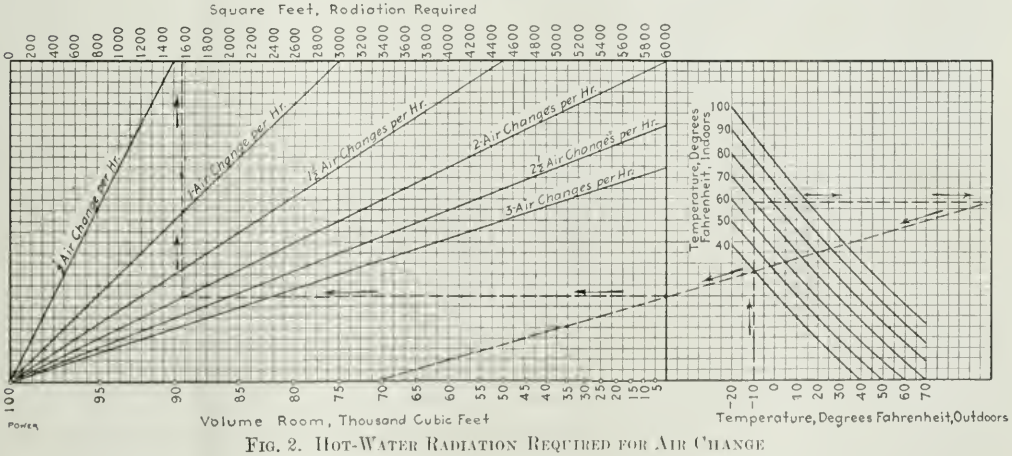


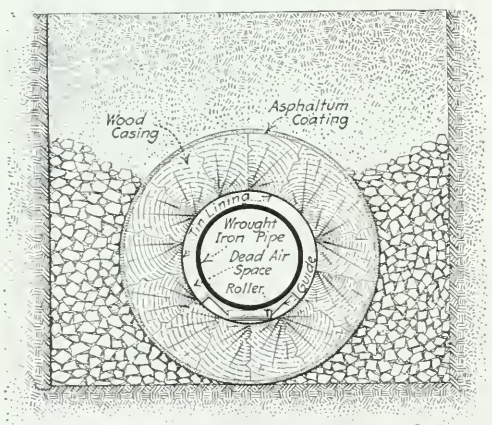
FIG. 2. HOT-WATER RADIATION REQUIRED FOR AIR CHANGE

the changing of air contents. The case illustrated by the dotted line is for a room of 70,000 cu.ft. in volume heated to 70 deg. with an outdoor temperature of 10 deg. below zero and assuming two changes of air per hour.

Beginning, as indicated by the arrows, at the scale of outdoor temperatures, rising to the curves for 70-deg. indoor temperature and horizontally to the right a halt is made at the vertical line on the extreme right-hand side of the chart. A straight-edge is placed to coincide with this last position and the point marked 70,000 cu.ft. volume of room. On the vertical line immediately to the left of the temperature curves the straight-edge locates a point from which a path is followed horizontally to the left until intersection is made with the line representing two air changes per hour. From this intersection vertically to the scale at the top of the chart gives a reading of 1570 sq.ft. of radiation necessary to heat the incoming air.

Wooden Pipes and Casings

In the olden days, wooden pipes were the standard water main. Common pump logs with the bark on were used. In some cases the lasting qualities of these logs were remarkable. In 1613, London laid 400 miles of elm logs, and in 1862 some of them were removed in good condition after being down 249 years. Detroit had 100 miles of these pump logs and they have been in use in various other states in the Union. The ordinary log,



Section through Underground Steam Main

however, would not stand much pressure. For the high pressures now employed it was necessary to reinforce the pipe with iron banding. A better joint was required and a coating which would make the exterior impervious to moisture. Since 1869, the Michigan Pipe Co., of Bay City, Mich., have been working on these points and have evolved a wooden pipe which will withstand a water pressure of 200 lb. per sq.in. For the exacting requirements of steam heating a modification of the above pipe has been adapted as a casing to surround the underground piping of the system. The larger casings are made up in 6-, 7- and 8-ft. sections of white pine or Michigan tamarack staves, which are dressed on the edges to conform to a circle and are fitted with a tongue and groove the full length. The staves are banded together with galvanized wire. A mortise is put in one end, and a tenon on the other, so the sections can be driven together. In the coating rolls the outside surface is covered with a thick layer of hot liquid asphaltum. The pipe is then rolled in sawdust, given a second coating of asphaltum and rolled again in the sawdust.

A shell 4 in. thick is considered standard, although 3- and 2-in. shells are used in some cases. In a certain test on underground steam pipe surrounded by a 4-in. casing a loss of steam of only 0.038 lb. per lb. per sq.ft. of pipe surface was reported. When this is compared to 0.840 for bare pipe with a temperature difference of 280 deg. between the air and steam, the insulating qualities of the casing will be better appreciated.

Pipe Sizes for Forced Hot-Water Heating

Answering Mr. Kent's question, in the Apr. 29 issue, regarding the method of determining the total friction head in order to use the tables for pipe sizes given by the writer in the Apr. 1 issue, I desire first to call attention to a confusion in the wording of the first sentence at the top of the second column. The meaning is evident, but the following sentence relieves any doubt: A more logical method would be to fix the total friction head and from the total length of the system determine the allowable friction head per 100 ft.

To determine the most economical relation between size of piping and size of pump a modification of Lord Kelvin's rule for the most economical section of an electric conductor may be used. His rule is that, "The annual interest on capital outlay should be equal to the annual cost of energy wasted." For forced hot-water work the interest and depreciation on the cost of the piping and covering plus the cost of the loss due to radiation should equal the interest and depreciation on the cost of the pump plus the cost of pumping the water.

If different total friction heads are assumed and the size of pipes for each head determined by the table mentioned above, and the various interest and cost charges computed, two curves can be plotted. The ordinates should be "dollars" and the abscissas "total friction head." One curve is plotted between friction head and the interest and loss charges for the piping system. The other curve is plotted between friction head and total interest and cost on pumping the water. Where they cross will be the friction head to use.

This method may, however, be found to be too long and complicated, and fairly close results may be obtained by assuming the total friction head. For the smaller installations a friction head of 35 to 40 ft. is used, running up to 80 ft. with the largest single installations or a small group of moderate-size buildings. For large installations where there are a large number of buildings or the circuits are very long the friction heads run up to 120 ft.

In the example given by Mr. Kent no length is stated, but suppose the total run is 3000 ft., and assume a friction head of 60 ft. This will give a friction head of 2 ft. per 100 ft. of length. Then from the table it is found that the main should be 4½ in., the branch with 1200 ft. 2 in. and the branch with 400 ft. 1¼ in.

Brooklyn, N. Y. W. L. Durand.

EDITORIALS

Discrimination

In an effort to justify its charges an electric company will certify to a public-service commission that it costs between four and five cents per kilowatt-hour to make, distribute and collect for current.

And then the same company will take a contract to sell the current which costs four or five cents for a cent or under.

Well, who is any the worse off?

The customer gets his current cheaper than he could make it, the small consumer pays no more than he would otherwise, and the electric company gets a considerable increase to its income at a comparatively small increase in expense.

But the same reasoning carried to its logical conclusion would lead into broad fields of discrimination. Imagine a manufacturer of some product of the delivered cost of which the freight is so large a factor that he could not run his factory or work his mine or quarry where it happens to be located and pay the regular schedule freight rates. Railroad trains pass his door in numbers every day. It would cost the railroad very little additional to hitch his car onto one of these trains and haul it to his market. If it were so hauled at a price considerably more than this additional cost, the industry would be kept alive, the manufacturer and his employees be furnished with profitable occupation, the users would enjoy the benefit of the greater supply and the railroad would make money, while those who paid the regular rate would pay no more than they had been paying.

But this would be discrimination and would not be tolerated. To allow it would be to put into the hands of the railroad power to ruin not only individuals but industries and towns.

A gas company cannot sell the same gas at one price for lighting and at another for heating, nor in many states is it allowed even to give large consumers an advantage in the rate. How far are the courts and the public-service commissions going to allow the electric companies to go with this kind of discrimination? This is one of the most weighty and interesting questions in the power-plant field.

In the last analysis, from a social-economical point of view the question of the displacement of the isolated plant by central-station service ought to be settled upon the broad engineering consideration of ultimate cost. How can the service be rendered most efficiently?

If the problem of operating the varied industries of a large city at the least cost and at the best efficiency were submitted to a competent engineer, he would, in our opinion, neither put in an immense central station nor continue the numerous makeshift, uneconomical, separate installations for each several building or industry, but by grouping the plants of city blocks or neighborhoods would evolve a lot of good-sized efficient plants with favorable load factors, important enough to warrant the employment of good engineers, and capable of furnishing heat as well as light and power. Such a block plant, when a considerable proportion of the exhaust steam can be used for heating, etc., will produce and deliver light, heat and power cheaper than any central station can do so at a profit upon any reasonable basis of competition.

⁂

Selection of Men and Equipment

Asked the source of greatest trouble in their large plants, several chief engineers have replied that labor troubles headed the list. These troubles, the cause of which may be traced directly to the labor, are not brought about through strikes, unions or dissatisfaction over wages, etc. They are the result of incompetent or neglectful workmen performing duties requiring skill, unceasing vigilance and strict attentiveness.

And here, as far as the chief engineer is concerned, lies the great difference between men and equipment. If a new turbine, condenser, boiler or stoker is needed, the selection of the best, or the best for the particular plant, is not such an exceedingly difficult matter. Books have been written, tests conducted, voluminous data compiled —all to assist in determining what kind, type or make of unit is best for any particular purpose.

Not so with men. They may bring references and diplomas galore, but these are not always a true indication of how well the men will perform the duties they are hired to perform.

The labor, skilled and unskilled, that the average chief engineer hires, is to him much like an apparatus the worth of which cannot be definitely determined without trial.

It behooves every man to be as good as he says he is and better than his employer thinks he is.

⁂

To Men in Charge of Auxiliaries

In large plants the chief or assistant chief engineer cannot constantly watch every piece of apparatus. The assistant engineers are usually too busy in the engine room to make frequent inspection trips through the cellars, pump rooms, etc. They must, therefore, depend much upon the men in charge of auxiliaries to perform their duties well without being watched over.

It is only after an oiler, helper, pumpman, coal conveyor operator, etc., has assumed the responsibilities of engineer that he can fully appreciate how valuable a careful and honest oiler or helper is. To feel that you have a man on watch with you who is giving all the assistance that he can, and in whom you have confidence, is indeed a factor that lightens the burden and worries of the working day.

Little oversights and things of which you say, "Oh, I forgot" become a regular occurrence through repetition.

It requires only reasonable attention to stop the coal conveyor when the last car or wagon has been unloaded. To run it longer unnecessarily uses power and wears out

the machine long before it should go to the junk pile. And the vacuum cleaner: there is no reason why it should be left running after the porter has sent word that the cleaning is finished. Neither should the cleaning of the oil and water filters and oil pipes be left undone until the engineer discovers that the boilers are scaled or the bearings are hot or destroyed. Nor should cleaning the boilers of soot be neglected until the firemen complain that they cannot "hold the steam."

Anyone assigned to a particular part of the plant should by all means make that part show that it is being well cared for. If little things go wrong they should be fixed without the formalities of a report. If the nature of a trouble indicates that something serious may happen if repairs are delayed, that should be reported at once. If one waits for the engineer to come and find the trouble it may be too late to avoid a shutdown.

Catalog Distribution

Often a manufacturer will expend considerable effort and money in the preparation of a high-grade catalog or handbook only to defeat his own ends by the overcautious manner in which he restricts its distribution. That this is so was shown by an incident that happened in a large university of the Middle West. A student asked the instructor if the ——— pump was the only good one on the market. He was at work on the problem of designing a power plant and the ——— Pump Co.'s catalog, containing full data on the pumps put out by that company, was the only one found in the classroom library, although the instructor had made repeated efforts to secure catalogs or, at least, some general data on pumps of a variety of makes.

It seems that an inquiry from any but an obviously good prospect for a sale is often treated with slight attention. This is surely short-sighted.

The main function of a catalog or handbook is to predispose the reader to favor articles of a certain manufacture. And this predisposition cannot be developed too soon. What is more natural than for a student to go out into business life with a preference for the make of pump he specified for his first, although imaginary, power plant? Both sentiment and familiarity cause him to lean in that direction. These likewise cause him to prefer a certain type or make of chimney, boiler, stoker, heater, engine, dynamo, etc., right down the line.

It may be true in a certain measure that, as Emerson said, the world will beat a path to the door of the chap who makes a superlative mouse trap or other product, even though he locate his factory in the heart of the backwoods. However, the beating process is usually insuperably long unless accelerated by these modern highly developed road-making machines, advertising and salesmanship, both of which are but specialized modes of disseminating information.

The discerning manufacturer realizes this, for he scatters the seeds of information broadcast. To him it mattereth not if some few do fall by the wayside, some on barren ground and some, perhaps, among thorns. He knows that these lost ones cannot be less fruitful than if left to grow antiquated in the vault or storeroom so that they finally have to be thrown away as no longer suitable for distribution.

Safety Valve Rating

An interesting book on the above subject is reviewed on page 727. Safety valves have always been a prolific source of discussion and numerous rules are in effect governing their size. In all, the results are expressed in valve area, which is the area of the disk exposed to the steam pressure when the valve is closed. The rule in use by the United States Board of Supervising Inspectors of Steam Vessels assumes a lift of the disk equal to one-thirty-second of the valve diameter, and the Massachusetts rule assumes that the orifice opening shall be one-eleventh of the boiler-connection area, which for bevel-seated valves would fix the vertical lift of the disk at about one-thirty-first of the diameter. In either case the lift is supposed to increase with the size of the valve. As a matter of fact, it has been shown that safety valves do not lift in proportion to their diameters. The lift is practically the same for all sizes and smaller if anything for the larger valves.

Both rules are based on Napier's approximate formula for the flow of steam through an orifice, and maximum grate areas, for which each commercial size of valve may be used, enter into the question. Apparently the above assumptions will allow variation, but factors of safety introduced in each case insure a valve of ample size. Even if the various sizes of valve did not have the same lift, the formula could be reduced to a simple expression involving the diameter rather than the area, such as the one proposed in this paper some four years ago and mentioned in the review already referred to.

Dividing the weight of steam to be delivered per hour by the absolute pressure is simple. Then, with a constant of one-tenth, derived by fixing the lift at a certain definite height for all sizes, shifting the decimal point one place to the left gives the diameter directly. This is the dimension that is always required, but with the present rules further computation or reference is necessary to derive the diameter from the area.

To make a valve lift in proportion to the diameter is possible. If it is desired a modification of the above simple formula would answer and it might be made to include some allowance for higher lifts at low pressure and *vice versa*. This would mean complication, and after all safety and simplicity are the considerations of paramount importance.

As stated in our editorial in the Mar. 9, 1909, issue, the purpose of a rule for safety valves is not to determine with mathematical precision the exact area required to discharge a given amount of steam per second, but to indicate a size of valve which will be ample for that service without being so large as to discharge the boiler too quickly or to be extravagant in cost. The proposed rule will indicate such a valve in terms of the diameter. It is simpler and safer than the present rules, as above certain limits it specifies valves a trifle larger, which will readily discharge the assumed amount of steam in a given time.

Due to lack of space it was impossible to give the full context of the author's arguments in the review. It will be found worth while to read the book, and as the subject of boiler safety is all important, we will be glad to receive discussion or comment on the points raised by the author.

READERS WITH SOMETHING TO SAY

Simplified Formulas

Two rules or formulas for finding the capacity of tank in U. S. gallons and for finding the heating surfaces of boiler tubes are given below, which are, I think, more easily worked than the rules given in the Engineers' Study Course, as they are worked out by multiplication, no division being necessary.

Rule: *To find the capacity of a cylindrical tank in U. S. gallons, square the diameter in inches, multiply by the length or height in inches and multiply the product by the constant 0.0034.*

Formula $D^2 \times H \times 0.0034 =$ *capacity*

Proof $0.7854 \div 231 = 0.0034$ *the constant*

Rule: *To find the heating surface of boiler tubes, multiply the diameter of the tubes in inches by their length in feet and that product by the constant 0.2618.*

Formula $D \times L \times 0.2618 =$ *heating surface*

Proof 3.1416 *cir.* $\div$ 12 *in.* $= 0.2618$.

U. S. G. Way.

Clearfield, Penn.

❖

Power-Plant Curves

The curves plotted on the accompanying chart were worked up from a daily report sheet similar to the one shown on page 779 of the Nov. 26, 1912, number of Power. This chart was drawn up to cover a period of one week, and the items noted are: Outside temperature, temperature of the water in the hot-water heating system, temperature of the feed water, amperes carried by the generator and coal used on each watch. All of the exhaust was used in the building heater and feed-water heater. Live steam was used for heating outside buildings, which at that time was not measured. The variations of the different items and their relations to each other can be grasped more readily than from a set of figures.

On the first day, which was Sunday, it may be noticed that the load on the generators was light. The night load from 8 p.m. to 7 a.m. is about 125 amp. and is nearly the same every night. The day load from 7 a.m. to 8 p.m. is heavier and not always the same. On Dec. 18, which was a very dark day, many more lights were used in the offices and the load reached its highest point, which was about 800 amp. The extra exhaust steam caused the temperature of the feed water, and the water in the heating system to rise. The coal consumption was the same as on Dec. 19, when the load was much lighter. This was caused by a lower outside temperature which required more live steam to be used for heating.

The steam pressure is not plotted as it was steady at 100 lb., and would appear as a straight line, and likewise the exhaust pressure which was steady at 1½ in. vacuum, and the voltage at 225 volts. This chart can be drawn up to fit almost any set of conditions. It may cover a space of 24 hr., one week or one month, as desired, and the readings, which, in this case, were taken every two hours, may be taken as often as found convenient.

To plot the curves the sheet is first laid off in squares, as shown, or paper may be purchased that is ruled in this manner. Next the figures at the left and bottom of the chart are put down and the values from the daily report sheet plotted in the proper place on the chart. For instance, the temperature of the feed water at 9 a.m.,

Curves from Power-Plant Log

temperature of the water in the hot-water heating system, temperature of the feed water, amperes carried by the generator and coal used on each watch. All of the exhaust was used in the building heater and feed-water heater. Live steam was used for heating outside buildings, which at that time was not measured. The variations of the different items and their relations to each other can be grasped more readily than from a set of figures.

Dec. 16, was 162 deg. Locate a point between the lines corresponding to 160 and 165 deg., and between the vertical lines that represent 8 and 10 a.m. The next reading showed a temperature of 168 deg. at 11 a.m. Locate a point in the proper place, and draw a line from one to the other. When the other points are located in the same way the rest of the curve may be drawn. Different styles

of line should be used for the different curves so that they may be easily traced and compared with each other. If it is desired to make one of these charts for every day or week it would be well to have them printed with all lines and figures in place. Then it will be necessary only to plot and draw in the curves.

If these charts are studied closely, they are sure to result in better economy and the engineer will have an intimate knowledge of what the plant is doing.

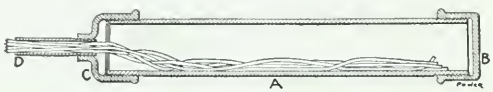
J. C. Hawkins.

Hyattsville, Md.

Torch for Boiler-Inspection Work

Some time ago there appeared in Power a description of a holder for a lamp to be used inside boilers. This ingenious arrangement brought to my mind a torch (by no means a new one) in use for the same purpose, which, possibly, does not require the care necessary with the lamp, as this torch burns equally well in any position.

One advantage of this torch, aside from the great convenience in inspecting boilers and in working in any dark restricted space, is the ease with which it may be made. Its great simplicity puts it within the reach of any handy man who has access to a hacksaw, a set of pipe dies, a vise and a few pipe fittings.



Section of Home-Made Torch

The illustration shows probably the most convenient size. A piece of 1¼-in. brass pipe *A* has a cap *B* on one end and a 1¼x⅜-in. reducing coupling *C* on the other. Into the coupling is screwed a ⅜-in. nipple *D*, about 2 in. long. A few strings of lamp wicking long enough to reach the bottom, complete the torch. Unscrew the coupling from the pipe, fill with kerosene oil, and it is ready for use.

J. F. Mowat.

Joliet, Ill.

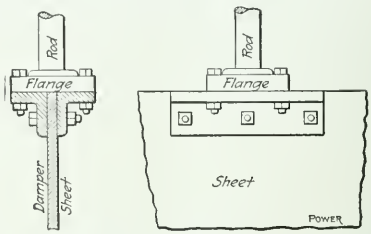
Troubles of Down-Draft Systems

The most common and, at the same time, the most annoying difficulties that arise in the operation of down-draft furnaces and systems are: Broken damper stems, both in the main flue and in the individual boiler settings, dampers held shut by collection of soot about the base, dampers rusted in their lower bearings, and last, but not least, leaks in the settings.

If the management will not bear the expense of forged stems, get a piece of rod or pipe, of a size and length necessary to suit, thread one end of it for a pipe flange, and bolt it to the top of the damper with two pieces of angle iron, as shown in the sketch. The rod or pipe should be securely headed down or peened into the flange so as to prevent its being screwed out. This repair on a broken stem may be quickly and cheaply made, yet it is strong and durable.

Many boiler men are familiar with the practice of laying a piece of perforated pipe along the base of the damper and blowing live steam through it to remove soot from around the damper base. The practice is to be condemned.

If the flue is not well drained, the water, which is almost certain to collect in it, will cause considerable annoyance by rusting the lower bearings of the damper stems, causing them to stick or jam in place, often resulting in twisting off the top stem without moving the damper. Of course, this trouble can be prevented by providing proper drainage for the flue, but in order to prevent a repetition of this trouble, bore out the lower bearing and place a brass bushing in it, allowing the stem to rest in the bushing. As the rust from the stem will have no effect on the brass, no further difficulty will be experienced with dampers rusting in one position. If the temperature of the flue gases is not too high, babbitt may be used instead of brass.



Construction of Damper Parts

Leaks in the flue or settings are a source of constant trouble, annoyance and loss to the plant. Uneven settlement of the boiler settings is responsible for most of these leaks, and here again, the old adage of "an ounce of prevention is worth a pound of cure" comes to mind.

With induced draft, leaks in the settings will cut down the CO_2 percentage at a startling rate. This, of course, means a big loss of fuel. Again, slow fan speeds, coupled with leaks in the flue, result in dense clouds of smoke and gas, which, although not particularly detrimental, are very disagreeable and annoying, and, in some cases, may even be the cause of serious accidents.

There are other troubles and annoyances in the operation with the down-draft system, but the above are the most common.

W. C. Cooper.

Springfield, Ill.

Welding Boilers

Boilers have been repaired by the use of both the acetylene-welding process and by the electric weld. It has been my experience that insurance companies frown on the use of the former process. Whether or not they approve of the electric-arc process I do not know.

An article on this subject should prove very interesting reading. If either or both methods are not satisfactory it should be widely known, while in justice to the makers of this type of apparatus the reasons should be given.

The only objection I have ever heard given against the use of autogeneous welding is the possibility of defective workmanship. If this is the only reason, it would seem as though this might be overcome by having the work done by competent operators, approved by the insurance officials. If these processes are not objectionable, it is evident that the upkeep cost of boilers may be reduced.

John Bailey.

Milwaukee, Wis.

Home-Made Reducing Valve

Fig. 1 is a reducing valve that answers its purpose very well on a heating system that does not require the use of an expensive reducing valve.

Any globe valve of the proper size and having the seat and disk in fairly good condition may be used. To convert a globe valve to a reducing valve, remove the wheel and file the threads from the stem until the latter moves easily through the bonnet. The lever and its support may be secured from a discarded pump regulator.

To determine the weight to be used to secure the desired reduced pressure, the reduced pressure is subtracted from the boiler pressure, and the problem is then that of a lever safety valve with the difference between the boiler pressure and the reduced pressure as the blowing-off pressure.

Fig. 2 shows a device for grinding the seats of blowoff

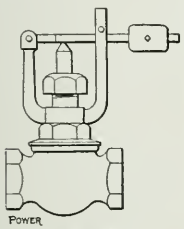


FIG. 1. HOME-MADE REDUCING VALVE

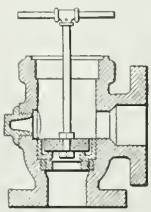


FIG. 2. VALVE RE-SEATING DEVICE

valves of the type having a flat seat and a disk containing a babbitt ring.

The grinder is a small alundum wheel of the same diameter as the valve disk. The handle is made of ¼-in. pipe; the grinding wheel being held between two locknuts on the end of the pipe.

A tee on the end of the pipe and two short pieces of pipe screwed into it furnishes grips for the handle. The stone is then turned on the seat with a downward pressure. Care should be taken when working on a brass seat as a very little grinding will make the seat as good as new.

GEORGE COLLISTER.

Salina, Kan.

Hole Worn through Piston

For rather unusual experiences, one which I recently had may be of general interest.

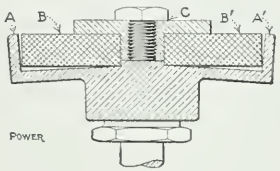
The engine in the plant to which I was sent acted as though it was working against a very high back pressure. Examination of the piston showed a hole worn through both sides of it from a bolt which had been left in it since it had been repaired.

W. M. LAY.

Irondale, Ala.

Repair to Valve-Disk Holder

It occurred to me that probably the monkey-wrench had played an important part in causing the valves in question to leak. On taking the valve apart we found the cause of the trouble. At *A* and *A'* is shown how the disk holder had been sprung, to all appearances, by excessive pressure brought to bear on the disk at *B* and *B'*, undoubtedly caused by an overdose of monkey-wrench treatment applied to the valve wheel. I removed the retaining nut *C*, took out the disk and screwed the nut down on the stem to within $\frac{1}{32}$ in. of the bottom of the holder.



BENT GLOBE VALVE-DISK HOLDER

I then heated some babbitt metal, filled the holder to the top of the retainer. After it cooled I put it in a lathe chuck and faced off the bearing surface and this valve now holds tight.

CHARLES W. DUNLAP.

Depew, N. Y.

Trouble with Leaky Boiler Tubes

In our plant is a 72-in. horizontal tubular boiler containing 72 four-inch tubes, and I am bothered with the two outside rows of tubes leaking at the back ends. I have replaced these tubes twice in the last two years, and they are leaking again; the rest of the tubes have never given me any trouble and they seem as good as new.

Will some reader of POWER kindly tell me why these tubes give out while the rest remain tight?

E. H. HART.

Baskett, Ky.

Flue-Gas Readings for Criticism

The accompanying table is a record of one day's sampling of our flue gases. I would like to have readers criticize this record. It will be noticed that a minus sign is put before some of the CO readings. This sign indicates that the CO reads less than the O.

Time	B	CO_2	O	CO	Draft
10.05	4	18.8	2.	1.2	0.15
0.25	3	14.6	5.8	0	0.4
0.35	1	16.0	4.	0.3	0.2
0.45	4	15.8	4.2	0	0.46
11.00	3	15.6	4.8	—0.2	0.4
0.16	1	17.0	3.8	0.	0.53
0.30	4	17.2	2.8	—0.2	0.3
0.32	3	13.0	7.8	0	0.18
1.10	4	16.4	2.6	—0.2	0.2
0.28	3	14.8	4.6	0	0.25
0.45	1	14.6	5.2	0	0.32
2.10	4	14.4	6.4	+	0.38
0.25	3	14.4	5.4	0	0.26
3.00	4	14.8	4.2	0	0.24

I would like to have it explained why this occurs for some readings and not for others. The samples were taken from horizontal return-tubular boilers operating at 140 lb. pressure.

F. A. LOWE.

Boston, Mass.

[Readers submitting flue-gas analysis readings should state the kind of fuel used, the draft in inches, the method of firing and the kind of furnace and boiler used. This information will enable readers to comment on the readings and arrive at conclusions that are not mere guesses. —EDITOR.]

QUESTIONS BEFORE THE HOUSE

The Deadly Monoxide

By his article, in the Mar. 18 issue, under the above caption, Mr. Calloway has probably performed a good service in calling attention to the fact that a high CO percentage is not desirable in a boiler furnace. However, some of his statements are hardly correct.

He states that when the "expert" first noticed the CO percentage it was 14 per cent., and that it reached 15 per cent.; then being within 2 per cent. of its dangerous point. If he intends to convey the idea that carbon monoxide with a percentage of 17 under atmospheric pressure and of a temperature, such as exists in the combustion chamber of a boiler, will unite with the oxygen present and cause an explosion, he is wrong. As a practical proof, recall that in a gas producer the CO often reaches 23 to 25 per cent. with a temperature much greater than in the combustion chamber of a boiler and at a higher pressure (this is in the pressure type of producers). Under such conditions the CO will not become explosive until it unites with air, or rather oxygen, at a high pressure or at a temperature 500 deg. higher than the temperature in the combustion chamber.

As another example one might mention a number of types of stokers using forced drafts with sealed ashpits. With these stokers when the fan stops, due to high steam pressure, the amount of air entering the furnace is at a minimum and but little CO_2 is created. Up to the present time I have heard of no installation being wrecked, due to the CO uniting with the air that might enter through the walls.

However, 15 per cent. CO is entirely out of question in a boiler furnace, and I rather suspect his "expert" should have renewed his chemicals in the CO recorder or was an amateur in the handling of it.

L. H. Morrison.

Kansas City, Mo.

If Mr. Morrison is correct that there is no possibility of an explosion when the Orsat apparatus shows a CO reading of 17 per cent., then R. H. Thurston made a surprising mistake when he wrote his book, "Steam Boiler Explosions in Theory and Practice." Quoting from page 126 of this book: "Explosions of gas sometimes precipitate steam-boiler explosions Should the gases leaving the fuel and the furnace not be completely burned, but become so mingled in the flues as to produce an explosive mixture, combustion finally occurring, the shock may be sufficient to cause rupture of the boiler, and as has actually sometimes happened, its explosion."

Recently E. J. Rimmer wrote a book entitled: "Boiler Explosions, Collapses and Mishaps," based on data gathered by the British Board of Trade. He illustrates various points by referring to actual cases and on page 86 I find this reference to what happened in Case No. 1687.

"The gases from the flues passing from the boiler through the chamber came into contact with an overheated economizer, which ignited the gases and wrecked it."

Furthermore, Mr. Rimmer states that the temperature of this overheated economizer was high enough to cause combustion of the gases. As an economizer contains feed water, even in an "overheated" condition, its temperature could not have exceeded the normal temperature of the flue gases very much, so it is reasonable to suppose that at some point between 400 and 800 deg. the gases exploded.

There is no doubt that CO often reaches 25 per cent. in a producer without wrecking the plant. In the first paragraph of my article, it is stated that "it (CO) is, *when mixed in proper proportions with air* highly dangerous, because of its explosive quality." Well behaved producers get no air above the coal, where the CO is. Unfortunately, boilers do. As to the "much greater" temperature of the producer fire as opposed to a boiler's it might be pertinent to point out that coal burned to CO_2 produces, roughly, 14,000 B.t.u. per lb., whereas in burning to CO, only 4400 B.t.u. can be squeezed out of the same amount of coal. Also 2750 deg. is not unusual in a boiler furnace.

The other "proof" that Mr. Morrison relies on is the case of stoker-fired boilers with sealed ashpits and forced draft. He evidently thinks that practically no air enters the ashpit when the fan stops. Under these conditions the only avenue of entrance for the air is through a duct usually of several square feet cross-section in which the only obstructions are the blades of a fan, set edgewise. In fact, the free area is just the same as when the fan is running. And there is the fire in the furnace to induce a draft.

H. R. Callaway.

New York City.

Isolated Plant vs. Central Station

Allow me to answer some of my critics who quote other instances as a proof that the particular case to which I referred, in my former article, appearing in the Jan. 7 issue, was wrongly analyzed.

I am not "evidently promoting central-station interests," and no one in my particular territory has installed one-half as many isolated plants as I have in the face of the most strenuous, but generally fair-minded, opposition on the part of the public-service corporation.

My critics object to $20,000 per year as the cost of 185 kw. of generating capacity. I made no such statement. The figure given included generators and engines, switchboard, wiring, foundations, some 300 meters, piping, pipe covering, engineering and incidental expense; and the sum total was taken from actual competitive bids for the various classes of apparatus.

Just why 5 per cent. for depreciation on what is spent for labor is improper, I cannot understand. Certainly nothing depreciates so rapidly as the labor involved in erecting a plant, as it has no second-hand value; and when the plant is worn out, no part of the labor value can be recovered.

Mr. Eastman, in the Apr. 15 issue, objects to my figure of 4.8c. per kw.-hr. The present prices for that same building are $2400 per year for a fixed charge and less than 1c. per kw.-hr. for running charges, which includes the free renewal of lamps, if anyone wants to use the carbon-filament lamp; and most of the tenants do.

I repeat that the exhaust steam available from the isolated plant will be of little value. There are very few days in the year when the exhaust steam from the elevator pumps is not, in part, escaping to the atmosphere. In my own offices (which are in this building), it is a rare occurrence to have the steam turned on at all. On very cold days considerable steam is required throughout the day; but by 4 o'clock in the afternoon the building is thoroughly warmed, and it is probable that the temperature would not fall 5 deg. between 4 and 6 o'clock if all of the steam were shut off. The exhaust steam of a 100-kw. load would be practically useless. The exhaust steam of a 25-kw. load, through the day, might be useful; but no central station would make a favorable rate to a customer running an isolated plant for the steady load and purchasing current during peak hours only.

At present, a very small amount of labor is required, and that not high priced. The additional labor requirements to operate a plant, respond to the demands of the tenants, test and repair meters, and, in general, perform the functions of a public-utility corporation on a small scale, would add a very appreciable amount to the present costs.

Mr. Hickman's estimate of the cost of fuel, in the same issue, would hardly apply in this section. Instead of $2.50 per ton for coal, it costs, in this vicinity, nearly $4.50 per ton in front of the boilers.

It should be borne in mind that I was quoting a particular case to illustrate that there were probably many instances where conditions were most unfavorable for isolated-plant operation; and that each individual case must be approached in a most impartial frame of mind. Since writing my first article the public-service corporation has displaced an isolated plant which has been in operation for ten years and which was in almost perfect condition. It had a total capacity of 350 kw., operated 18 hr. per day, and had an unusually high load factor. A complete set of books had been kept in connection with this plant since the day it started, and the actual costs of operation were positively known. Nevertheless, the public-service corporation made a rate which left no room for choice, and that after allowing an excessive amount of fuel for heating purposes alone.

The plant has been running since November, 1912, on central-station service; and at the present writing the contract proves to be a most satisfactory one. Why? Because the central station makes a favorable rate; and that is the whole answer. It is not necessary to compare that rate with other rates, or to question whether it is just.

We very often lose sight of the fact that small power plants do not operate within the estimated costs. There is seldom brought to bear any considerable amount of executive ability, such as is exercised in the conduct of the main business; and this is no reflection on the actual operators of power plants. I admit that the central-station rates in Boston or New York make the isolated plant more than a possibility; but I was not, nor am I, writing about rates in Boston or New York. I am simply trying to state that what obtains in one place, or even one instance, is seldom of little value in another instance, except as it adds to the general fund of information and broadens a man's view. If some of the doubting Thomases are really interested, I shall be glad to give them figures which will prove that the isolated plant has a hard struggle for existence when the central-station rates get down to 1½ and 2c. per kilowatt-hour.

WARREN B. LEWIS.

Providence, R. I.

Available CO_2 Percentages

"Available CO_2 Percentage" is the subject of an article appearing in the Apr. 15 issue. The writer of the article gives a method for determining the available or theoretical maximum percentage of CO_2 for any given coal when the fixed carbon content is known. This information, if well founded, would prove very comforting to some engineers, particularly those in Missouri, where we burn coal containing as low as 33 per cent. of fixed carbon. To go a little further into the subject without becoming too technical is the object of the present discussion.

Theoretically perfect combustion of a coal may be expressed as combustion in which all of the combustible constituents of the fuel have been completely burned and further, that the products of combustion contain no excess air as indicated by the presence of free oxygen. Therefore, an Orsat analysis of the products of combustion from coal burned under theoretically perfect conditions would show only carbon dioxide (CO_2) and nitrogen (N). In other words, there would be no oxygen (O) or no carbon monoxide (CO) present. If the fuel were pure carbon, the analysis would show approximately 21 per cent. CO_2 and 79 per cent. nitrogen.

Carbon appears in coal in the form of free or "fixed carbon" and in combination with hydrogen, commonly known as "volatile matter." Under favorable conditions the carbon in the volatile matter burns to CO_2 and the hydrogen to water (H_2O) while under unfavorable conditions of combustion the volatile matter may appear in the products of combustion as unburned gases, tar and particles of free carbon or smoke.

In flue-gas analyses made with the ordinary three-pipette Orsat apparatus, the unburned hydrocarbon gases are not detected, or, in other words, they appear erroneously as nitrogen. If these unburned hydrocarbon gases are present in large quantities, as, for instance, when a coal containing a high percentage of volatile matter is burned in a poorly designed furnace and with an insufficient air supply, they produce a condition known to every Orsat operator as "low totals." Another cause for low totals is the hydrogen in the coal. Hydrogen requires for combustion eight times its weight in oxygen or thirty-five times its weight in air and the product of its combustion is water (H_2O), which, of course, does not appear in the Orsat analysis. Those who have analyzed gases from boilers in which natural gas is used as fuel are, no doubt, familiar with the very low totals obtained, due to the high percentage of hydrogen in this fuel.

When Mr. Pohlman in his calculation states that 11.7 per cent. of CO_2 is the theoretical maximum for coal containing 70 per cent. of fixed carbon, he neglects to take

into consideration the composition of the remaining 85.3 per cent. of the flue gases. There could in such a case be no free oxygen or carbon monoxide present; otherwise combustion would not be perfect and if this 85.3 per cent. was truly nitrogen, what has become of the oxygen which, in the form of air, might account for the presence of this unduly large amount of nitrogen?

A simple calculation will show the impossibility of this combination:

$$85.3 \times \tfrac{21}{79} = 22.7 \textit{ per cent. of oxygen}$$

In other words, 22.7 per cent. of oxygen must have originally accompanied the 85.3 per cent. of nitrogen in the form of air, and, since one volume of O combines with carbon to form one volume of CO_2,

$$22.7 - 14.7 = 8 \textit{ per cent. of O}$$

which must have disappeared from Mr. Pohlman's calculation. In order that this disappearance might be due to the presence of hydrogen there would be required, by a somewhat complicated calculation, approximately 16 per cent. of hydrogen in the coal. This is, of course, an absurdity, since the available hydrogen content of a coal containing 70 per cent. of fixed carbon is only about 4.5 per cent.

The writer is of the opinion that the available or theoretical percentages of CO_2 are not the criterion in an effort to approach perfect combustion. A more suitable method of procedure is to practically disregard the CO_2 and depend entirely on the O and CO. Perfect combustion is approached as these two quantities approach zero, but since the CO has a tendency to increase as the O decreases, care must always be taken to keep the former within proper bounds; otherwise the loss on one side will more than offset the gain on the other.

CO_2 recorders are of value only when the nearest possible approach to perfect combustion has been determined by means of complete flue-gas analyses and careful study.

E. J. Billings.

St. Louis, Mo.

A. Pohlman's letter on available carbon-dioxide percentages contained some statements which appear to be based on a slight misunderstanding of the principles of combustion. It is quite correct that pure carbon burned in air under laboratory conditions would produce a flue gas with a maximum of 21 per cent. of CO_2. It is also true that most coals would not produce that amount of CO_2 when burned under the most favorable conditions. The maximum amount of CO_2 obtainable cannot be obtained in the simple manner stated, i.e., by multiplying the percentage of fixed carbon by 0.21.

The constituents of coal that are determined by what is known as a "proximate analysis" are: Moisture, volatile matter, fixed carbon and ash. Assuming ideal combustion for maximum CO_2 production, we would have to supply enough air to furnish oxygen not only for the combustion of the fixed carbon, but of the volatile matter also. This volatile matter varies with different coals, and is usually composed of some CO_2, some free hydrogen and nitrogen, ammonia, sulphur and a large proportion of complex hydrocarbons, ranging all the way from benzene and methane to anthracene and the heavy tars.

It is evident, therefore, that there is much carbon in this volatile matter, and that its combustion will produce CO_2, which will swell the total produced from the fixed carbon. Assuming 3 per cent. moisture, 30 per cent. volatile, 60 per cent. fixed carbon and 7 per cent. ash, the CO_2 from the volatile will be about one-fifth of the total CO_2. This is based on the assumption that the volatile matter is one-half carbon by weight and this is a conservative estimate.

The remainder of the volatile matter, the hydrogen, sulphur and ammonia will consume oxygen without producing a corresponding amount of CO_2, and, therefore, would dilute the flue gases, thereby reducing the percentage of CO_2. This dilution would not be in direct proportion to the relative percentages of carbon and hydrogen. One unit of carbon requires two and two-thirds its weight of oxygen for combustion, while a unit of hydrogen requires eight times its weight of oxygen for combustion. The relation between volatile matter and carbon-dioxide percentages is, therefore, not nearly so simple as the formula Mr. Pohlman assumes.

The percentage of moisture and ash would tend further to complicate the calculation of the carbon dioxide obtainable from the fixed carbon in the coal. So far as the combustion is a purely chemical reaction, they are absolutely inert. In other words, if we took a pound of pure, dry carbon and burned it completely with the right amount of air, we would get the same heat value and the same CO_2 value as we would if the pound of carbon was well ground and mixed with inert matter like sand, clay, limestone, etc., which would closely resemble the ash in ordinary coal.

Mr. Pohlman well states that the determination of CO is important. It would seem that the percentage of oxygen in the flue gas is equally important. One constituent shows if there is a deficiency of air, and the other if there is an excess. It is well known that there must be considerable excess air with most coals and boiler designs, but no definite rules can be laid down. Each coal and each boiler design and setting modify the conditions to such an extent that only an actual test will furnish accurate information. Only enough excess air should be added to keep the CO less than three or four-tenths of 1 per cent.

It should be stated in this connection that it has been found in most cases that the above conditions are best realized when the CO_2 content is the highest. This is so because any decrease in the amount of air below the most efficient figure would reduce the CO_2 by the formation of CO, from lack of oxygen. On the other hand, any increase in air would dilute the gases so that the CO_2 would be lowered. A complete analysis should be made at convenient intervals as a check on the CO_2 recorder, and to insure the proper combustion of the fuel.

C. H. Southern.

Birmingham, Ala.

Names for Steam Stuff

Supplementing my letter in the Apr. 8 issue, suggesting "hydrol" as a name for wet steam stuff, how is "hyperdrol" for superheated steam or "pyr-hydrol"? It is made up of hyper + hydrol, or it can be hy + (pyr = fire) + drol = hyperdrol or pyrhydrol.

Really the last, "pyrhydrol," is the better.

C. S. Palmer.

Newtonville, Mass.

INQUIRIES OF GENERAL INTEREST

Ball-Gage Cock Packing—What is the best packing for ball-gage cocks?

H. F.

Most ball-gage cocks are made to receive sheet packing. Plumbago sheet packings are preferred by many.

Pumping Water from Air-Tight Elevated Tank—Can all of the water be pumped from an air-tight tank 15 ft. above the pump?

E. J. K.

All of the liquid water could be pumped out, but a vapor of water would fill the space after the water was removed from the tank, all of which could not be pumped out.

Tungsten Lamp Discoloration—Why do some tungsten lamps, after burning for some time, appear as though the inner surface of the globe is plated with copper?

T. H. W.

Lamp manufacturers seem to disagree upon the composition of this deposit. Some claim that it is an oxide of tungsten due to the presence of the trace of air it is impossible to exhaust from the bulb. Others attribute it to impurities in the tungsten which have vaporized out under the high temperature and condensed on the glass.

Erratic Safety Valve—A 4-in. lever safety valve ground tight in its seat, set to blow at 100 lb., starts to blow at 80 lb. and will not stop until the pressure falls to 60 lb., unless the valve is pressed down to its seat. When additional weight is put on the valve it will not blow at 100 lb. What is the matter with the valve?

H. F.

The valve may be ground tight, but has not a good straight beveled seat all around. It probably has been ground rounding, for the action described is due to the valve getting cocked on its seat.

Corliss Dashpot—What is the function of the dashpot on a Corliss engine and how does it work?

J. P.

Its main purpose is to quicken the action of the steam valves in cutting off. A dashpot works similarly to a piston working in an air cylinder. On the upstroke it holds the valve-releasing gear to its position, and, a partial vacuum being formed in the dashpot during the upstroke, the piston is forced down in the cylinder by atmospheric pressure assisting the cutoff to quicker action. The dashpot itself is cushioned on its down stroke by a small amount of air admitted under it during its upstroke by a small cock provided for that purpose.

Required Size of Wire—Some machinery, situated about 200 ft. from the dynamo (334-kw., shunt-wound, direct-current, 30-amp., 125-volt) is to be driven by a 5-hp. motor. Is it allowable to connect the motor on the same circuit with four 16-cp. lamps? What size wire should be used?

B. F. H.

The motor may be connected on the same circuit with the lights. The size wire to be used will depend largely upon the voltage drop allowed between the generator and motor. Allowing a drop of three volts a No. 4 wire might be used. This is capable of carrying 65 amp., if rubber covered, and 92 amp., if covered with weatherproof braid. A No. 6 wire which, rubber covered, may carry 46 amp. and, weatherproofed, 65 amp., will cause a drop of 5 volts between the two machines. With smaller wires the drop would be greater. The No. 6 wire would be large enough. It would carry a 50 per cent. overload without serious heating and the generator could easily be excited to give 5 volts higher pressure than required by the motor.

Corliss Valve Advantages—What advantages have Corliss valves over slide valves? What advantages have they in condensing engines?

J. P.

Corliss-valve advantages are mainly that they offer less frictional resistance to motion than slide valves; that they are controllable directly from the governor; that they can be operated and regulated by the governor so as to remain wide open until the proper point of cutoff is reached, and will close quickly with little or no wire-drawing effect; that they allow shorter steam passages and less percentage of clearance space. Their advantage in condensing engines is that they can be made to give a sharp cutoff without wire-drawing the steam, and, consequently, a full effect of expansion in the high-pressure cylinders and give a full opening of the valve until the point of cutoff in the low-pressure cylinders. Another advantage is that with Corliss valves the exhaust valves being placed on the bottom of the cylinders there is less danger of water accumulating in the cylinders, because the exhaust ports afford drainage by gravity.

Loss of Voltage—A shunt field dynamo (33 kw., 1125 r.p.m., 250 volts, 80 amp.) loses about 50 volts in four hours' running under load with the rheostat turned as far as it will go. When the load is off it will excite to 300 volts. It gets very warm but not injuriously hot when the load is on. The engine does not decrease in speed. What is the trouble?

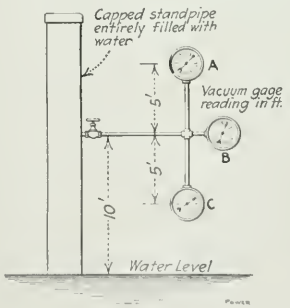
P. S.

From the symptoms the loss in voltage is due primarily to friction of the brushes, causing them to heat up and chatter and also deposit carbon on the commutator. This increases the resistance and tends to reduce the voltage. An application of oil to the commutator when warm would probably remedy the trouble. It should be put on sparingly with a piece of canvas or other material that will not deposit lint. Graphite brushes also might help. If the commutator is rough, it should be smoothed.

Pressure in Standpipe—Referring to the accompanying diagram, what will be the readings of the three gages as shown when the capped standpipe is entirely filled with water? What would be the readings if the gage pipes were first drained of all water before the valves were opened?

W. F.

The pressure at the water level is atmospheric (14.7 lb., or 33.947 ft., or, roughly, 34 ft.) At any point in the standpipe the absolute pressure will be less than that equivalent to a head of 34 ft. by the height of the point under consideration above the free water level. Where the gage pipe attaches, therefore, the absolute pressure will be equivalent to a head of



$$34 - 10 = 24 \text{ ft.}$$

This, then, will be the reading of gage B. Gage A being 5 ft. higher, its reading will be 5 ft. less, or 19 ft., and gage C being 5 ft. below B, its reading will be 29 ft.

If the gage pipes were first drained of water they would become filled with air at atmospheric pressure. Thereafter, if the valves were opened some of this air would escape into the standpipe until the pressures were again balanced. Water would displace all air in the horizontal pipe and the vertical pipe on gage C. The air in the pipe of gage A would remain pocketed. The pressure on gage B would be 24 ft., as before; on gage C 29 ft., as before, but on gage A it would be the same as on gage B, 24 ft., except for the subtraction of a head of air of 5 ft., which would be negligible.

ENGINEERS' STUDY COURSE

Analysis of Coal

Those who tackled the problems given in the concluding paragraphs of the last section may be anxious to know how they succeeded, so we will work out the answers now before getting down to the subject of the day.

Substituting in the formula preceding the questions, the weights of carbon and hydrogen per pound of coal given in the problem, we have

$$W = 11.52\,C + 34.56\left(H - \frac{O}{8}\right)$$

$$W = 11.52 \times 0.7875 + 34.56\left(0.05 - \frac{0.02}{8}\right)$$

$$W = (11.52 \times 0.7875) + (34.56 \times 0.0475)$$

$$W = 9.07 + 1.64 = 10.71\ lb.$$

air required per pound of coal. As the weight of the products of combustion always equals the weight of air required plus the weight of the combustibles themselves, we have

Wt. of air required + *Wt. of carbon* + *Wt. of available hydrogen* = *Wt. of products of combustion*

$$10.71 + 0.7875 + 0.0475 = 11.54\ lb.$$

In finding the weight of air required for the combustion of the fuel oil, exactly the same formula is used as in the case of coal, except that the available hydrogen, represented by the term $H - \frac{O}{8}$, is given and, as a result, our work is simplified,

$$W = 11.52\,C + 34.56\left(H - \frac{O}{8}\right)$$

$$W = (11.52 \times 0.8485) + (34.56 \times 0.1115)$$

$$W = 9.77 + 3.85 = 13.62\ lb.$$

of air required per pound of oil. And, in the same way as before, the weight of the products of combustion are

Wt. of air required + *Wt. of carbon* + *Wt. of available hydrogen* = *Wt. of products of combustion*

$$13.62 + 0.8485 + 0.1115 = 14.58\ lb.$$

According to the definition previously given, a B.t.u., or unit of heat measurement, is the amount of heat required to raise the temperature of 1 lb. of water 1 deg. F. In the third problem there are 7575 lb. of water per hour to be raised in temperature. Then,

$$197.5 - 73 = 124.5\ deg.$$

$$7575 \times 124.5 = 943.087\ B.t.u.$$

are being put into the water per hour.

Coal Analysis

When you analyze a fuel you find out what it is composed of. In previous lessons we saw that the combustible or burnable makeup of all fuels consists of a few elements: Carbon, hydrogen and sulphur. Besides these combustibles a fuel contains oxygen, nitrogen and ash.

Now as the heat value of a fuel depends upon the amount of carbon, hydrogen and to a slight extent sulphur which it contains, it may be important to know what the analysis or makeup of a given fuel is so as to be able to estimate what amount of heat ought reasonably to be expected from its combustion under the boiler.

Ultimate Analysis

There are two kinds of fuel analysis; they are called ultimate analysis and promixate analysis. The ultimate analysis tells the amount of carbon, hydrogen, oxygen, nitrogen, sulphur and ash which the dry fuel contains. In other words, ultimate analysis means complete analysis, giving the proportions of all the constituents.

To make an ultimate analysis requires expert skill, costly apparatus and a much more advanced knowledge of chemistry than we need for our study here. Ultimate analyses are seldom attempted by any but expert chemists in regular laboratories suitably fitted for the purpose. However, reports of ultimate analyses of the coal or oil of a certain district, seam or mine are often available, and, consequently, it is well to know what an ultimate analysis is and how to use it in estimating the heat value of a given fuel.

Proximate Analysis

The approximate, or as it is usually called, proximate analysis, gives the amounts or percentages of moisture, volatile matter, fixed carbon and ash contained in the fuel.

Coal is about the only fuel to which the proximate analysis is applied, although, of course, the proximate analysis of any solid fuel can be made. The proximate analysis of fuel oil is practically useless as in the average case there would be but one item, the oil being nearly all volatile matter.

The moisture is, of course, the amount of water which the coal has soaked up and this is liable to vary in a given coal from time to time, depending on the way the coal is stored, state of the weather, etc.

The volatile matter consists principally of the hydrocarbons described in the first lesson on this subject. When we say that a thing is volatile, we mean that it can be changed from the solid, the semi-solid or from the liquid state into a vapor fairly easily, and without having its nature changed; that is, without undergoing a chemical change. Quicksilver, or mercury, is a liquid-like metal which can be turned into a vapor, therefore, mercury is volatile.

In fuels, the hydrocarbons can be changed into vapors at fairly low temperatures and driven off without being burned, hence, they are called volatile. These hydrocarbons exist in a great variety of form; that is, although they all consist of nothing but hydrogen and carbon, the proportion of each varies greatly, making substances of different characteristics. Thus, marsh gas, or methane, has the chemical formula CH_4; acetylene, C_2H_2; olefiant gas, C_2H_4; ethane, C_2H_6, etc. Each combination has its own physical qualities. Some, known as "light" hydro-

carbons, have the quality of vaporizing at fairly low temperatures while others, known as "heavy" hydrocarbons, do not vaporize until the temperature becomes very high. For instance, gasoline is a very light hydrocarbon, as it changes into a vapor at about 200 deg. F., while cylinder oils are composed of heavy hydrocarbons because they remain liquid at temperatures as high as 600 deg.

The fixed carbon is the pure or uncombined carbon which remains after the heating process has vaporized the hydrocarbons: it can be driven off only by actual burning and not by any process of vaporizing or distillation.

The ash is simply the unburnable solid matter which fuel contains, and consists principally of slate, dirt, etc.

The proximate analysis is not difficult to make and it is valuable in comparing one lot of coal with another, in estimating the heat value and in checking up furnace operation.

The proximate analysis consists simply of heating an accurately weighed sample at a low temperature, for a certain length of time to dry out the moisture. The sample is then weighed again: the loss in weight divided by the original weight is taken as the percentage of moisture. The second heating (at a higher temperature this time) and the third weighing give the volatile matter. And from the third heating (at high temperature) and

FIG. 1. DIAGRAM OF METHOD OF QUARTERING SAMPLE

fourth weighing, the fixed carbon and ash are determined. Details of the method will be given later.

TAKING THE SAMPLE

There are really two steps to be taken in securing a proximate analysis: First, selecting the sample; second, making the analysis itself. The reliability of the results depends upon the care taken with each step.

In selecting the sample, the object is to secure a small quantity of coal which represents the average character of a very large quantity. If the coal were of uniform character all the way through, or if the lot to be sampled could be thoroughly mixed or stirred, it would be an easy matter simply to pick up a few lumps or handfuls at any convenient point and use them as the sample to analyze. But as such is not the case it is necessary to select many small quantities from all parts of the lot, of such size that when all are put together the pile will be small enough to thoroughly turn and mix after which a suitable sample can be taken therefrom. No exact rules can be offered to suit all cases, and the method of sampling must be adapted to the local conditions. If the quantity of coal to be sampled is large, care must be taken to avoid making the sample pile too large to work thoroughly, yet, at the same time, the pile must be composed of as many small samples as possible in order that it will closely represent the real character of the coal.

One commonly used method where coal is received in carload lots is to make a corer which can be driven down through the coal in several places in the car. This method gives samples of the coal from top to bottom at the various points, and when thoroughly mixed these samples may be taken as a fair average for the whole car. The corer may be made out of heavy 2- or 2½-in. iron pipe, 5 or 6 ft. long, sharpened at one end and with the other end capped or reinforced so that it can be driven with a sledge. Enough samples should be taken with the corer to make a large sample of 50 to 100 lb. Any lumps in this large sample should then be crushed so that there are no pieces larger than ½ in. diameter, after which the sample should be thoroughly mixed and "quartered down" until about 5 lb. remain.

This "quartering down" is done by spreading the sample out thin in the shape of a circle; dividing this circle into quarters, and throwing away the first and third quarters, as shown in Fig. 1. Thus, the quantity is reduced one-half. The two remaining quarters are then mixed thoroughly, spread out and again quartered. This process is continued until the remainder of the sample is of the desired size.

If the sample is not to be analyzed right away it should be put into a glass jar or a tin fitted with a tight cover and stored in a reasonably cool place until used.

Annual Dinner of Heating Engineers

May 12 was the date, and the place was the Engineers' Club. The annual dinner of the New York Chapter of the American Society of Heating and Ventilating Engineers was a great success. Just 148 enthusiastic rooters sat down to table and under the skillful guidance of the jovial toastmaster, Homer Addams, spent a most enjoyable evening.

After the cigars and coffee stage, C. R. Place was called upon to explain the mysteries of the Grand Central Station, which covers an area of 80 acres. Three-wire, direct-current service and forced hot-water heating are supplied through a series of tunnels from a central station. The water travels 7000 ft. to supply 500,000 sq.ft. of radiation and for the coming winter 100,000 sq.ft. of radiation in the Belmont Hotel will be added. All heating is done by direct radiation, and ventilation, with air washers and humidity control, is effected with tempered air. The two track levels below the surface are supplied with 1,000,000 cu.ft. of air per minute.

John F. Hale spoke of the old days in Chicago when the first chapter of the society was formed, and commented on the remarkable growth of the New York chapter. Their influence and that of the Boston chapter had been a salient factor in the success of the parent body. Before their organization it had been hard to get together. Much was left for the annual meeting and very little was accomplished.

"Industrial Education" was the topic of F. G. McCann, president of the chapter. He is greatly in favor of the vocational school, where the aptitude of the pupil is sought, and he is trained in the particular line to which

he is best suited. Besides learning a trade the student is instructed in citizenship and is developed into excellent material for a thoroughly good mechanic.

In these days specialization is so marked that there is no place for the apprentice. One gang may rough in the installation, another put in the risers, still another the fixtures, a fourth the brass work and so on. Each gang becomes expert in their own particular work and are kept at it. An apprentice might work for years and only become familiar with one phase of the subject.

In the past Great Britain has supplied many of the best steam fitters and plumbers. The loss of her best men was the cause of a raise in wages, so that she is now holding on to them and we must look elsewhere. The trade schools of some of the larger companies have not worked to their own advantage. The coöperative school in Cincinnati has given good results, but there most of the manufacturers are engaged in the one line of machine-tool building. In New York it would be difficult to get together all the firms of one line without considering the others, so that the same system would probably result in failure.

The broad training obtained in vocational schools is desirable and it is to them that we must look for the best material to carry on our trades.

A. S. Armagnac talked "shop," his subject being "Publicity." He referred to the unfortunate condition of the public and the engineer not getting together on a common basis. The public will not talk in engineering terms and the engineer sticks to the phraseology of his profession. A little coöperation is needed. Chicago has a heating and ventilating engineer and so has Cleveland. Every city in the country should have a board of heating and ventilating engineers. This is publicity of the right kind, and to obtain results the members of the chapter and the parent body must pull together and boost the cause.

The "kid in engineering," George G. Schmidt, spoke of the difficulties encountered by the young man. He appealed to the kids of yesterday to "loosen up" and give the novice the benefit of their experience. Books were at hand and plenty of them, but the older men of experience were needed to pick out the "coal." A course in heating and ventilation conducted at the headquarters of the chapter was suggested.

Dr. H. H. Franklin was the last speaker. His subject was "Purification," and was illustrated with numerous stories that were right to the point, and brought home to his listeners the proper use and benefits of ozone.

BOOKS RECEIVED

ENGINEERING THERMODYNAMICS. By Dr. Charles E. Lucke. McGraw-Hill Book Co., New York. Cloth; 1188 pages, 6x9½ in.; 328 illustrations; tables; indexed. Price $8.

AIR COMPRESSION AND TRANSMISSION. By H. J. Thorkleson. McGraw-Hill Book Co., New York. Cloth; 201 pages, 6x9½ in.; 143 illustrations; plate; tables; indexed. Price $2.

PRACTICAL MATHEMATICS. Part IV. By Claude I. Palmer. McGraw-Hill Book Co., New York. Cloth; 147 pages, 4½x7 in.; 68 illustrations; tables; indexed. Price 75 cents.

⁂

A new heat indicator is a bright red paint which turns almost black before reaching the boiling point and resumes its normal color when it cools again.—"Compressed Air Magazine."

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

In a convention city recently an enterprising but tactless dry goods dealer displayed this sign:

OUR VISITING DELEGATES SHOULD AVAIL THEMSELVES OF OUR OFFER FOR THIS DAY ONLY: SHIRTS RETAILED AT WHOLESALE PRICES.

Across the store front was this one:

FORCED TO RETIRE. TROUSERS ONE-HALF OFF!

The latter is one good reason for retailing the shirts.

⁂

You eat pie with your lunch? Then watch out for a feller the pure-fooders call Ben Zoate, of Sody, wherever that is. Of course, if your brand is the good old home-made product that mother used to mold, you're in right; if your pie is molded in a pie foundry or after a chemist's formula, the pure-fooders say you're in danger of being pizened, sure.

⁂

Can you can power? You can power, Rollo, if you can call a battery a can. Everything is canned these days from suds to songs, from lobster to illumination. Frinstance, supposing you are eating up the road at 60 miles an hour on your way to work in your auto and suddenly your standardized batteries give out. You stop at a garage. To have them recharged and wait steen hours? Can that old stunt! Your batteries are whipped out, other standardized and charged batteries are whipped in, you throw in the clutch—and you're off ag'in, Finnigin. Canned power did it. Don't believe it? Well, by the time some of us have bought an electric car (meaning a motor car) this will have come to pass; perhaps sooner. The scheme sounds feasible—and fees-ible.

⁂

A special tug has been built to assist in "nosing in" the "Imperator" when she comes to New York. The tug is 118 ft. long, 27.5-ft. beam, and has 1100-hp. in engines. Its speed is 14 knots.

⁂

CONVENTION TIME

By Billy Spills

It's here at last for some of us! So let's dust the old suitcase, pack our extra shirt and socks, our typewritten speech, a flask of good "lining for our under-flannels," our return ticket and some stogies, and we'll be all dolled out for that convention "which this year promises to exceed all previous efforts."

The National Electric Light folks will be toted to Chicago in what they call "pink," "golden poppy" and "maroon" special trains. Well, they've got the kale to indulge in these flossy things if they want them. It sure sounds classy.

As for us, we're going to Springfield, Yonkers, Newark, Terre Haute, Toledo, Milwaukee and elsewhere in the good old way. We'll dig up a corner in the smoking-car alongside some feller that years ago we used to fire with in the Sunnyside power plant, and we'll swap smokes and our "cure" for rheumatiz; we'll blow about our kids; tell what we'd do with the plant if we owned it, and fix a warm place in Gehenna for the central-station folks—if we belong to the "isolateds"; we'll have our little gabfest about the turbine and the reciprocating engine; we'll be so dum glad to see each other that—

Say, bo! the good old way is the only way. You and I don't want any of the flossy things in ours, do we?

We're going to do our duty to old man Uplift and Mister Goodoftheorder when we get on the grounds, and in between we'll have the time of our lives for a few days. Then when we get back home we're going to make ourselves believe that the old job isn't such drudgery after all; that perhaps we went stale or sour for want of a rest-up or a glimpse of real scenery.

But, whisper! We're not going to bring home even one souvenir—if we can help it. You and I know there's always a few fellers in a big crowd that are too ding keen for the rough stuff, and sometimes they give the rest of us a bad name.

And whisper again; We won't intentionally offend any well-meaning party who forces a souvenir on us, but we're starting out bravely to do the right thing, and we hope to get away with it. So good luck be yours, boys—and Prosit!

NEW PUBLICATIONS

SAFETY VALVE RATING. By Alfred B. Carhart. Published by the Crosby Steam Gage & Valve Co., Boston, 1913. Cloth, 105 pages, 6x9 in.; illustrated; tables.

This interesting book with the above title is just off the press. The author, Alfred B. Carhart, does not believe in the present methods of rating safety valves. The rules now in common use for calculating the proper size of valve show valve area, and do not properly consider the lift. In his opinion it would be much simpler and more satisfactory to have the formula indicate the diameter, as was done by that suggested editorially in "Power" about two years ago by F. R. Low. In the first few pages of the book he cites his reasons, and compares the rules in most common use.

In equipping the steam boiler ordinarily used for power, safety valves are rarely smaller than 3 in. or larger than 4½ in. If for the four-valve sizes between these limits, it might be assumed or required that the lift be made the same, as is now quite fairly true in practice, then Mr. Low's formula might be used:

$$\text{Dia.} = \text{constant} \times \frac{W}{P}$$

in which W equals the total pounds of water evaporated per hour by the boiler (grate area × rate), and P equals the absolute pressure of the steam in pounds per square inch. By assuming a lift of 0.0875 in. for bevel-seated valves, or 0.06 in. for flat-seated valves, the formula reduces to the very convenient form of

$$\text{Dia.} = 0.1 \frac{W}{P}$$

If it is thought desirable to require the larger valves to lift higher than the smaller sizes, then it is still possible to formulate a rule in simple terms which will give the commercial diameter size directly and conveniently. When the lift is made a direct function of the valve diameter, increasing with the size of the valve, the general formula would be

$$D = \text{constant} \sqrt{\frac{W}{P}}$$

The objection should not be urged that this formula involves calculating the square root of the variable quantities, as a short table could be provided giving the maximum value of $\frac{W}{P}$ corresponding to each commercial valve size, and it would be only necessary to determine or memorize five or six values.

It would seem desirable not to make the lift of safety valves increase in proportion to the size of the valves. Such uniform increase in lift may appear to give a simple formula for calculation, but it does not work out well in practical application. To make the ratio of lift to diameter variable, would require factors of the second or third power in the calculations.

A new proposal is that valves used at lower boiler pressures may well be made to open more and to lift higher than valves at higher steam pressures. The strain upon the valve is not so great at low pressures, yet present rules assume that a certain size of valve will always lift the same amount, no matter what the working pressure is. This requires that for a boiler of given horsepower at 100 lb. working pressure, the proper valve must be almost double the size required for a working pressure of 200 lb., or half the size required at 50 lb. For at the lower pressures less steam would be discharged through a given area of opening, if the valve size and lift be fixed, since the quantities of steam discharged are in proportion to the absolute pressure, according to Napier's rule.

As the reaction and pounding of the valve or the wear upon the seat is much less at low pressure, the total spring load upon the disk being less, the valves might be allowed to lift higher for the lower steam pressures without increasing the practical difficulties. No rule thus far proposed takes this into account, yet it would be practicable to do this. All manufacturers could easily provide springs for each pressure, which would allow the valve to lift more for low pressures and restrict the lift for higher pressures.

Rather than make the valve lift vary with the absolute pressure it would be better to assume a certain fixed lift as the base of minimum, and allow an additional amount which would vary inversely as the pressure, the total of these two factors being the permissible total lift of the valve. It would only be necessary to fix upon the proper or desirable value of the lift for each valve size, and substitute these values in the calculation based upon the general equation.

$$D = \text{constant} \sqrt{\frac{W}{P}}$$

This is the rule preferred by the author.

An empirical rule is also suggested in which the desirable amount of valve lift for each case might be determined by taking into account past and present experience, with due allowance for considerations of absolute safety, the longest life and greatest certainty of satisfactory operation of the valves, comparing the various selected values with each other so as to make them suitably proportioned and bearing a fair relation to the present measured lift of safety valves, in so far as the practice of the several manufactures conforms to the best engineering judgment and requirements. Having set down a suitable lift arbitrarily fixed upon for each valve size and pressure, the corresponding steam discharges could be calculated according to Napier's formula, and tabulated for easy reference. The valve lifts determined would necessarily be considered as minimum requirements which all valves must at least show.

Each formula is fully discussed in the book, and the practicability of its use viewed from all angles. The subject is an important one, and those interested in this line would do well to read the book carefully. Although copies are to be sent out by the Crosby Steam Gage & Valve Co., the treatment was not written from a manufacturer's standpoint.

Kansas N. A. S. E. Convention

The first annual convention of the Kansas State Association, N. A. S. E., was held in Topeka, at the Commercial Club, on May 7 to 9. About 200 engineers attended.

At the opening session Mayor Cofran, of Topeka, made the address of welcome. "As we have been a builder and operator of engines for many years," said the mayor, "we have a sort of fellow feeling in common with you. As an engineer we installed the first engine in the city of Topeka for the operation of a newspaper plant that was known at the time as the 'Topeka Record.' We also sold the first engine used by the Atchison, Topeka & Santa Fé Ry. for its power plant."

L. E. Weaver, president of the association, responded in a few well chosen words. J. Will Kelley, secretary of the Commercial Club, made an address of welcome in behalf of the business men of the city. Wiliam Pulliam, assistant state secretary, responded and concluded by introducing National President McGrath, who spoke on the growth and standing of the association. The Rev. Mr. Corwine, of the Third Christian Church, pronounced the invocation.

Among the speakers were Fred Raven, secretary of the national organization, and John Dawson, attorney-general.

On Thursday morning a business session was held in the main room of the Commercial Club, and in the afternoon George H. Hodges and Prof. E. B. McCormick, of the State Agricultural College, made addresses.

Among the entertaining features was a picture show by the Topeka Commercial Club. The visiting ladies were taken to the Novelty Theater, on an automobile ride, and on a shopping tour by the local committee under Mrs. William Houser. On Friday evening the closing feature was a banquet at the Throop Hotel.

C. H. Van Dyke, of Atchison, was elected secretary. These other principal officers were reëlected for another year: President, L. E. Weaver, Kansas City; vice-president, E. S. Miller, Kansas City; treasurer, F. R. Hunter, Parsons. J. B. Dobbs, of Atchison, was elected state deputy. Trustees are: E. H. Burg, of Fort Scott, for one year; N. E. Vandyne, of Parsons, for two years, and William Pulliam, of Topeka, for three years. Fred Palmer, of Topeka, was chosen conductor, and H. A. Norton, of Port Scott, as doorkeeper.

Atchison was chosen as the next meeting place in 1914.

An interesing exhibit was made by the supply men in the Auditorium.

OBITUARY

SAMUEL L. MOYER

On May 3, after a brief illness, Samuel L. Moyer, first vice-president and general manager of the Lunkenheimer Co., Cincinnati, Ohio, died at his home in that city, in his fortieth year. Mr. Moyer was connected with the company for nearly

23 years and had worked his way up to the position he occupied at the time of his death by untiring energy and marked ability. He was prominently mentioned as a mayoralty candidate in his home city and had served two terms in its city council. Mr. Moyer was very generous, but giving of his means so quietly that few knew of his generosity. He was a member of the Cincinnati Business Men's Club, National Metal Trades Association, Queen City Club, Cuvier Press Club, and several others. He leaves a widow.

FRANCIS M. RITES

Francis M. Rites, the inventor of the well known inertia governor bearing his name, died suddenly at his home near Slatterville Springs, N. Y., on May 8.

Mr. Rites was born in Illinois in 1858. He was graduated from Cornell University with the degree of mechanical engineer in 1881, and was traveling engineer in 1883 for the Westinghouse Machine Co., and afterward a draftsman in the employ of Westinghouse, Church, Kerr & Co. Later he was steam expert for the Westinghouse Machine Co.

Mr. Rites' most conspicuous work was the Rites governor in its many forms and applications. It is so well known that its description and development need not be dwelt upon. In "Power" of July, 1902, Mr. Rites described the Rites governor and its adjustment and regulation. He was a member of the American Society of Mechanical Engineers and other technical societies. He was 55 years old.

HORATIO A. FOSTER

Horatio A. Foster, well known as an author, who had charge of the appraisal work of J. G. White & Co., died suddenly in New York City, on Apr. 27. Mr. Foster was born at Bustleton, Penn., on Jan. 12, 1858.

His electrical engineering training began in 1884, with the Daft Electrical Co. The following spring he was sent to Baltimore to electrify a short branch branch for the Baltimore Union Passenger Ry. Co., the first commercial electric railway in the United States. Later he went to the Thomson-Houston Electric Co., Lynn, Mass., and in the fall of 1888 he was superintendent of the East River Electric Light Co., New York City, remaining until July, 1891. He was then appointed an expert for the United States Census Office to compile data on the electrical industry of New York State, the only state which took an electrical census in 1890. Late in 1893, Mr. Foster became associated with Prof. Forbes, electrical engineer of the Niagara Falls Power Co. Early in 1895, Mr. Foster joined the staff of the Cataract Construction Co., Niagara Falls, as testing engineer for determining the cost of steam power, which work occupied about a year and a half.

After some years in consulting work, Mr. Foster was in 1901 appointed receiver of a brewery trust in Philadelphia which had failed. During this period he had also several important engineering undertakings. In 1906 he was placed in charge of L. B. Stillwell's work for the United Railways & Electric Co., Baltimore, in rehabilitating its generating and distribution system. In 1908 he was retained by Bion J. Arnold, Chicago, and assisted in appraising the property of the Metropolitan Traction Co., New York City, the Detroit United Railway Co., the Southern California Edison Co., Los Angeles.

Since that time Mr. Foster had been working on valuation of public utilities and studying traffic conditions and other matters pertaining to public service, being engaged in this work with J. G. White & Co. at the time of his death. Besides the "Electrical Engineer's Pocket-Book," Mr. Foster was the author of "Valuation of Public Utilities," and frequently contributed to the technical press. He was 55 years old and was a member of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Engineers' Club of New York and the Philadelphia Arts Club.

PERSONALS

J. B. Kitchen has been appointed engineer of operation of the Toronto (Ont.) Hydro-Electric System.

William D. Purcell has assumed charge of the rubber department of the Collieries Supply & Equipment Co., Philadelphia, Penn.

D. W. Roper, assistant chief operating engineer of the Commonwealth Edison Co., Chicago, has been elected chairman of the Chicago Section of the American Institute of Electrical Engineers.

Walter Knapp, formerly assistant shop superintendent of the machinery division at the Philadelphia Navy Yard, has accepted the position of chief engineer in the Cleveland office of the Standard Engineering & Drafting Co.

Frederick L. Ray, superintendent of the power plant of the Louisville (Ky.) Ry., won the first prize, $75, offered by the educational committee of the National Association of Stationary Engineers in its recent prize competition. Mr. Ray was successful in the advanced classification of the committee, in which thirteen papers were submitted, all of exceptional merit. Mr. Ray is chairman of the educational committee of Kentucky branch, No. 1, National Association of Stationary Engineers.

Seymour W. Cheney has been appointed operating engineer of the La Crosse (Wis.) Gas & Electric Co. Mr. Cheney is a graduate of the University of Wisconsin. He entered the gas and electric business in 1905 with the Denver (Colo.) Gas & Electric Light Co., and the following year was appointed superintendent of distribution of the Lincoln (Neb.) Gas & Electric Co. Later he held a similar position with the Montgomery (Ala.) Light & Power Co. Since 1910 he has been on the engineering staff of the Railroad Commission of Wisconsin, with headquarters in Milwaukee.

SOCIETY NOTES

The New Jersey State Association, N. A. S. E., will hold its annual banquet on Sunday afternoon, May 25, at the Continental Hotel, Newark. The dinner will conclude the convention, and a large attendance is expected.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being considered by the town council of Groton, Conn., for the installation of additional equipment in the municipal electric-light plant. T. A. Graves is superintendent of the plant.

The board of trustees of the Binghamton State Hospital, Binghamton, N. Y., are considering plans for the construction of a new power plant at the hospital. An appropriation of $60,000 was recently made for the purpose.

Estimates are being prepared by Horace G. Sweet, Utica, N. Y., of the cost of installing a municipal electric-light plant at Lyons, N. Y. Bonds to the amount of $10,000 have been voted for the purpose.

The common council of Newark, N. J., will investigate the cost of installing a new 50-kw. generator and engine in the City Hall lighting plant, to be used for supplementary service.

The West Penn Rys. Co. is planning extensive improvements to its power plant at Creighton, Penn. H. F. Banard, Pittsburgh, Penn., is purchasing agent.

SOUTHERN STATES

Plans are being prepared for the construction of an electric-light plant at Ravenswood, W. Va., for which J. Mentor Caldwell, Parkersburg, was recently granted a franchise.

Plans are being considered by the Monongalia Electric Co. for the construction of an electric-light plant at Star City, W. Va.

The Walterboro Ice & Light Co. is considering the construction of an electric-light plant at Walterboro, S. C. G. C. Brown is interested.

Bids will be received about June 30 for the construction of a municipal electric-light plant at Marshallville, Ga. Plans have been prepared by the J. B. McCrary Co., Atlanta, Ga.

The city of Lakeland, Fla., is planning extensive improvements to its municipal electric-light plant.

The Ball Creek Electric Co. is considering plans for the construction of an electric-light plant at Lone Mountain, Tenn. Payne Bros., of Lone Mountain, are interested in the project.

Extensive improvements are planned by the citizens of Paris, Tenn., to the municipal electric-light plant. M. W. Younkin is manager of the plant.

The B. F. McCormick Lumber Co., Winchester, Ky., will purchase ten electric motors for its planing mill, having decided to substitute central-station current for steam power.

CENTRAL STATES

Bids will be received by J. A. Wucher, clerk of the board of trustees of Jasper, Ind., until May 26, for furnishing equipment for the municipal electric-light plant. Paul H. White, Union Trust Bldg., Indianapolis, Ind., is consulting engineer.

The city council of Bloomingdale, Mich., has granted a franchise to Lewis K. Hawk, to construct and operate an electric-light plant.

Explosion and fire, May 7, destroyed the plant of the Lapeer Gas & Electric Co., Lapeer, Mich., with loss of $50,000.

It is reported that the Illinois Northern Utilities Co. will expend $100,000 for the construction of a new power plant at Belvidere, Ill.

Plans are being prepared by C. C. Chapman, Chicago, Ill., for the construction of a municipal electric-light plant at Elgin, Ill.

George Loptein has been granted a franchise to construct and operate an electric-light plant at Warren, Ill.

A new 225-hp. Diesel engine and a direct-current gen-

POWER

Vol. 37 NEW YORK, MAY 27, 1913 No. 21

The Operating and The Consulting Engineer

The operating and the consulting engineer have an interest in common. Both working to produce the most successful operation of power plants. Co-operating they can accomplish what is impossible for either if working single-handed. The more the operating engineer realizes the value of the consulting engineer's advice and the consulting engineer the value of the operating engineer's experience, the better it is for both of them.

Some operating engineers believe the consulting engineer to be an "undesirable." It requires no argument to show that this attitude is absurd. The misconception exists because in the early days of power-plant practice a consulting engineer was not required so often to check up the operating conditions. The competition in the field of power generation was not so intense and the operating engineer's position was more secure. Not so today.

With efficiency systems invading all establishments to effect more economical operation, the plant must show that it is worth operating. If it is not, it must give way to cheaper sources of power. The engineer's object then is to make his plant the cheapest source of power, in fact, his bread and butter depend upon it.

No one can help him more in doing this than the consulting engineer. This kind of work is his specialty.

When central-station agents propose to the plant owner the use of their service and the elimination of the isolated plant, the consulting engineer should make the test that shall decide whether central-station or isolated-plant service shall be used. The operating engineer should *insist* upon the calling in of a competent consulting engineer at such crucial times.

At other times as well the advice of a consulting engineer may prove of value. Even when everything is thought to be in the best condition it is worth while to be sure of it by having a test made occasionally by an outside expert.

This would not be an acknowledgment of incompetency on the part of the operating engineer, any more than an expert accountant's certification of a corporation's accounts reflects upon the accuracy of the office force.

If this practice should become prevalent in power plants, and it is likely to, it would be one of the greatest incentives for the engineer to keep his plant in the best possible condition. It would mean a higher recognition of him by his superior and betterment in every way.

Welcome the consulting engineer and don't despise his aid.

New Power Plant at Weber Wagon Works

By A. R. Maujer

SYNOPSIS—Description of a plant containing two 750-kw. bleeder-type turbines and water-tube boilers with dutch-oven furnaces, using a combination of wood refuse and coal as fuel. Circulating water from the condenser is cooled by a spray-nozzle cooling system.

There comes a time in the history of almost every manufacturing works when the increase in output requires either a substantial extension of the existing power plant or the erection of a new plant. Usually when such factors as age, condition and efficiency of the existing equipment

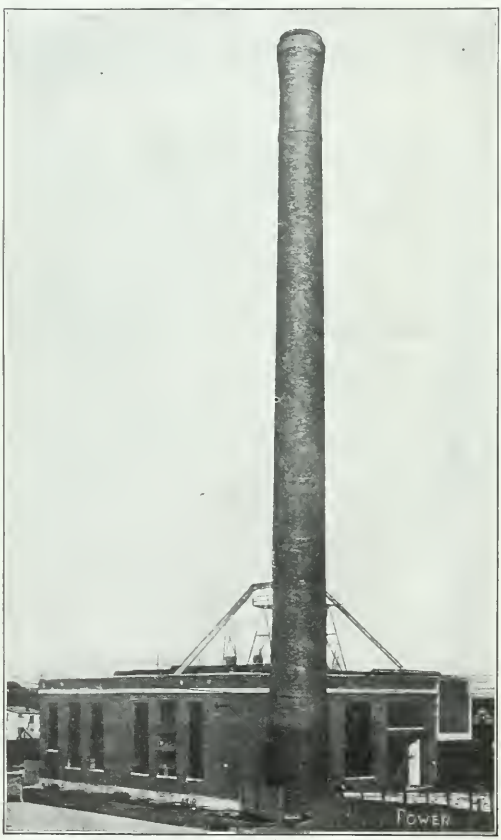


Fig. 1. Power Plant of the Weber Wagon Works

are taken into consideration and when attention is given to the prospects of still further expansion, a new plant is decided upon, which is laid out with the changed needs of the works as the influencing factor.

Such was the situation existing at, and the policy adopted by, the Weber wagon works of the International Harvester Co., located at Eighty-first and Wallace Sts., Chicago, Ill.

Original Plant

The old power plant contained four 250-hp. water-tube boilers, fired with a mixture of wood refuse and coal. The original power unit was a 24x48-in., 750-hp. Corliss engine, at 82 r.p.m. This unit drove, by a rope drive, a main shaft from which numerous countershafts distributed the power to the various machines throughout the works. Later, a 19x18-in., four-valve automatic engine was installed for driving a 200-kw., three-phase, 60-cycle current, 480-volt generator for lighting and some power service. During a few years just prior to the erec-

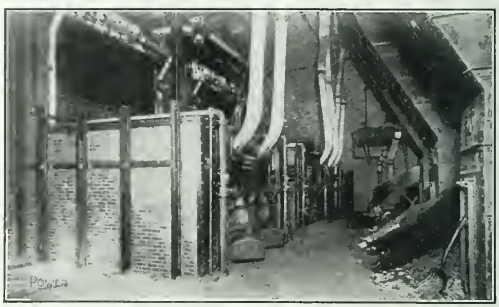


Fig. 2. Boiler Equipment

tion of the new plant, about 30,000 kw.-hr. per month were purchased from the central station.

Exhaust steam from the engines was used to heat the various buildings and some drying kilns by means of a combination direct- and indirect-radiation system.

With the installation of the new power plant the system of transmission was changed from shaft and belt or

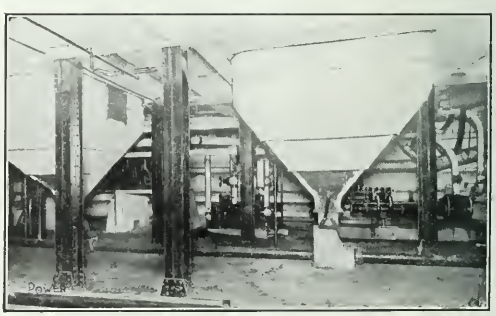


Fig. 3. Ashpits, Ash-Conveyor Pipe and Feed Pump

rope to electric drive, some 80 motors, of sizes from 1 to 50 hp., distributed throughout the plant, being used for individual or group drive, according to the requirements in each case.

New Power Plant

The new power plant is in a separate building across

Wallace St., some 50 ft. from the main works. It was decided to so house the power equipment because the fire hazard is considerably reduced thereby, an important consideration in a plant where much wood and other inflammable material is used. Then, too, it was important that the work of the plant be not interrupted during the process of changing and the separate plant was the best solution of this problem.

In Fig. 1 is shown the power house, a one-story-and-basement building, which occupies an irregular plot. The frame is of steel and the walls, roof and floors are of concrete, the outside walls being finished with a veneer of hard-burned red brick and inside walls with a wainscot of white enamel-faced brick, red brick above as high as the crane rail and common brick painted white above that. Windows, 8x25 ft. in size, are set as close together as possible, thus providing for maximum light and ventilation.

All of the equipment has been selected with an eye to economy and service as the sole objects in view, first cost being the last influencing factor. No opportunity has been neglected in arranging the apparatus for accessibility, on the principle that anything which is difficult to "get at" is almost certain to be neglected. The personal safety of the operators has been increased wherever possible by the employment of such devices as nonreturn valves, oil switches, etc., and their physical comfort has been provided for in the shape of locker rooms for clothing and sanitary lavatories and shower baths.

Boiler Equipment

Arrangements have been made for burning refuse in the form of shavings and sawdust from the works, with whatever additional coal is required to make up the needed amount of fuel. At present there are three 410-hp. water-tube boilers. The stack is large enough, however, to provide draft for at least five additional boilers of the same capacity. Each boiler contains 203 four-inch tubes 18 ft. long and two 34-in. by 18-ft. steam drums, giving an effective heating surface of 1098 sq.ft. The boilers are designed for a working pressure of 200 lb., gage, but the working pressure is only 150 lb., gage. Each boiler is equipped with a superheater, located in the last pass, and is guaranteed to superheat 18,000 lb. of steam per hour 75 deg. F.

Dutch-oven furnaces are used, as shown in Fig. 2, with stationary herring-bone grates, 8 ft. by 9 ft. 6 in. in size, having 76 sq.ft. of surface, 10 per cent. air space. Shavings and sawdust are delivered to the boiler room by air blast through a sheet-iron duct which discharges into two

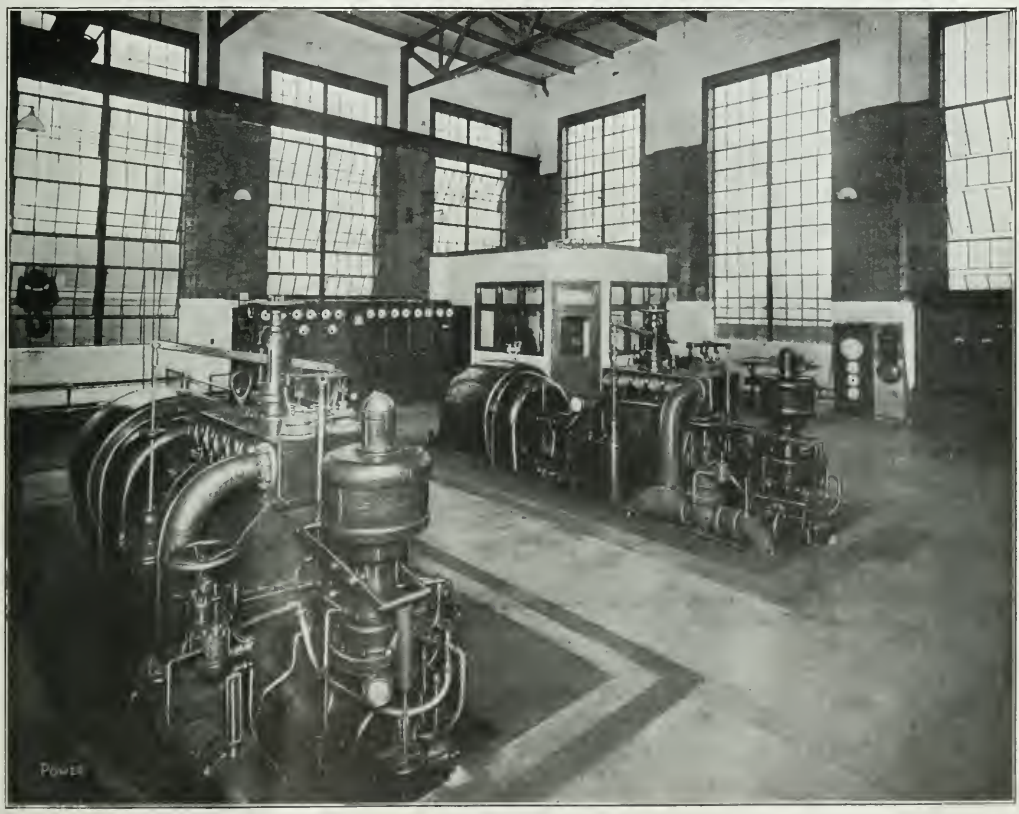


Fig. 1. Turbines of the Weber Wagon Works Plant.

"cyclone" collectors located on the roof. From these the fuel feeds by gravity either directly into the furnaces or into sheet-iron bins, along one side of the boiler room, in which any excess is stored.

When this excess is required in the furnaces it is discharged through hoppers in the bottom of the bins into a return air duct which again delivers the sawdust to the collectors on the roof from which it is discharged to the furnaces through feed spouts. Motor-driven agitators, located in the discharge hoppers of the storage bins, are operated when feeding into the return air duct so that the sawdust cannot become packed and choke up the discharge openings or the pipes.

generate three-phase, 60-cycle current at 480 volts. A 100-kw. noncondensing turbine unit, the exhaust from which is used in the heating system, is employed for service at night, on holidays and at other times when the load is light. There are two 25-kw. exciters, one driven by a motor, the other by a noncondensing turbine.

A most interesting feature about the main units is the bleeder arrangement and the operating economy secured. The turbines are designed on the combined impulse and reaction principle, having one impulse wheel acted upon by the velocity of the steam and an upper and lower reaction wheel acted upon by expansion. A bleeder tap is made at the point of connection between the upper and

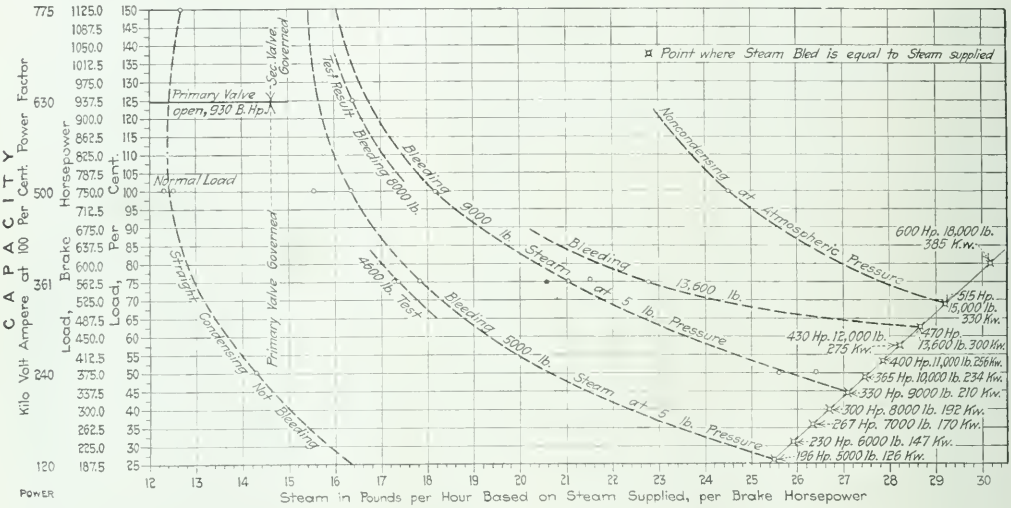

CAPACITY
Kilo Volt Amperes at 100 Per Cent. Power Factor
Brake Horsepower Load, Per Cent.
Point where Steam Bled is equal to Steam supplied
Primary Valve open, 930 B.Hp.
Sec. Valve Governed
Test Result
Bleeding 6000 lb.
Bleeding 9000 lb. Steam at 5 lb. Pressure
Noncondensing at Atmospheric Pressure
Normal Load
Straight Condensing Not Bleeding
Primary Valve Governed
4600 lb. Test
Bleeding 5000 lb. Steam at 5 lb. Pressure
600 Hp. 18,000 lb. 385 Kw.
515 Hp. 15,000 lb. 330 Kw.
470 Hp. 13,600 lb. 300 Kw.
430 Hp. 12,000 lb. 275 Kw.
400 Hp. 11,000 lb. 256 Kw.
365 Hp. 10,000 lb. 234 Kw.
330 Hp. 9000 lb. 210 Kw.
300 Hp. 8000 lb. 192 Kw.
267 Hp. 7000 lb. 170 Kw.
230 Hp. 6000 lb. 147 Kw.
196 Hp. 5000 lb. 126 Kw.
Steam in Pounds per Hour Based on Steam Supplied, per Brake Horsepower
POWER

FIG. 5. TURBINE TESTS

With this arrangement the firemen are never required to fire the sawdust by hand. Under present operating conditions the sawdust constitutes about 60 per cent. of the fuel, the balance being Illinois bituminous coal, hand fired. No special provisions have been made for handling the coal because the quantity used is comparatively small. The coal is delivered from cars on the siding alongside the boiler room into a bin adjacent to the plant from which it is wheeled in barrows to the furnaces.

Ashes fall into rectangular steel pits which discharge through hoppers to the conveyor pipe of a vacuum ash-handling system located on the basement floor, Fig. 3. The ashes are delivered to a storage bin over the railroad siding, from which they fall by gravity into a car.

The chimney is of tile and reinforced-concrete construction, 200 ft. high, and with an inside top diameter of 8 ft. 6 in. The breeching is of sheet iron, covered with 1½ in. of asbestos.

TURBO-GENERATORS

At present the main generating equipment consists of two horizontal automatic bleeder-type turbines, driving 750-kw. maximum rated dynamos of the revolving-field type, Fig. 4. The rating is based on 80 per cent. power factor and a temperature rise of 50 deg. C., under continuous operation. These units run at 3600 r.p.m. and

lower reaction stages and a certain amount of steam may be drawn off to supply the heating system throughout the works. The balance of the steam passes through the final stage and on into the condenser. The connection between the bleeder and the final stage is controlled by an automatic valve, which is set by weights to maintain a definite pressure on the heating system, usually 5 lb., gage. The bleeder valve may also be regulated by hand.

By this arrangement the steam required for heating is first made to do work in the turbine and all but the exact quantity of steam so required is fully expanded in the turbine. In addition to being operated in this manner the turbines may be operated noncondensing, passing all the steam to the heating system, or they may be operated condensing, when all the steam goes direct to the condenser and none to the heating coils.

Under normal operation in the summer each turbine furnishes about 5500 lb. of steam through the bleeders for use in wood-drying kilns; in the winter an additional 10,000 lb. of steam is bled from each for the heating system. Hence, the machines were designed with the low-pressure stage arranged to pass 5500 lb. of steam per hour less than the high-pressure, and they are most efficient when operating under this condition.

Each turbine is provided with a primary and a secondary inlet valve of the balanced-poppet type, both controlled

by the governor. Under operating conditions the primary valve is opened first and when wide open passes a quantity of steam at 150 lb. pressure, just sufficient for the normal load of the unit. The secondary valve then comes into action and when wide open will supply steam for the designed maximum overload requirements at maximum overload speed. Should the load increase still further the result would be a drop in speed and frequency. Each turbine is further provided with an overspeed device, which will automatically close the throttle when the speed reaches a predetermined rate. This device is set to operate when the speed reaches 20 per cent. above normal.

As customary, the turbines were tested at the shops of

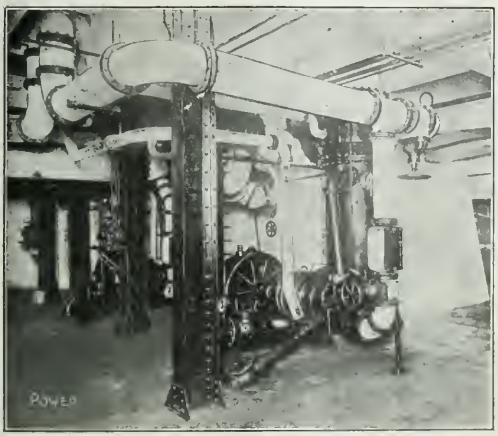


FIG. 6. CONDENSERS AND CONDENSER PUMPS

the builder in the presence of a representative of the purchaser; the results obtained are presented graphically in Fig. 5.

The condensers, Fig. 6, are located in the basement directly below the turbines. The circulating water and the air pump for each condenser are mounted on one shaft and driven by a single-stage noncondensing turbine.

The condensing water is taken from a 600,000-gal. concrete basin, located just south of the plant, which was installed primarily as a storage reservoir for a fire-fighting equipment. The return water from the condensers is cooled by passing it through spray nozzles, Fig. 7, located above the basin. The capacity of the circulating-water system is sufficient for a 2250-kw. equipment and it is capable of cooling the water from 100 to 70 deg. F. under the average atmospheric conditions at the plant. The piping is so arranged that if needed a motor-driven centrifugal pump can be installed to draw water from the basin and pass it through the spray nozzles at a more rapid rate than the circulating pumps provide.

PIPING

All the auxiliaries, including the boiler-feed pumps, and the piping are located in the basement. The steam is delivered from the boilers in 7-in. leads, controlled by automatic nonreturn valves, to a 10-in. main header, hung on brackets on the building columns in the basement directly beneath the wall between the boiler and engine rooms. From this header a 5-in. lead supplies steam to each main unit and to its condenser-auxiliary turbine through a 2-in. branch. The 100-kw. unit may be fed from either the main or the auxiliary header.

An 8-in. auxiliary header, lying close to and parallel with the main header, serves the fire pumps, the 100-kw. unit and the boiler-feed pumps only. With this arrangement it is possible, in case of fire, to shut down everything except these pieces of apparatus. The lead from the main header to the 100-kw. unit is 5 in. in diameter, reducing to 4 in. beyond a 2½-in. branch which supplies the exciter turbine. The lead from the auxiliary header is 4 in. in diameter and connects with the main-header lead half way between the headers and the turbine.

AUXILIARIES

There are two duplex Underwriter fire pumps, each 18 and 10 by 12 in. in size and capable of delivering 1000 gal. per min. at a pressure of 100 lb. per sq.in. when running at 70 r.p.m. These are located in the basement beneath an open hatch in the engine-room floor so as to be in sight of the engineer on watch.

One of the two boiler-feed pumps is a two-stage centrifugal, driven by a steam turbine at 3600 r.p.m. The suction, connecting with the feed-water heater, and the discharge pipes are both 3 in. in diameter. The other feed pump is a 10 and 6 by 12-in., pot-valve, outside end-packed duplex pump, bronze-lined throughout. The capacity of each of these pumps is 21,000 lb. of water per hour against a pressure of 150 lb. gage. The feed piping is in duplicate throughout. The steam piping for these pumps is also in duplicate, one pipe connecting with the main header and the other with the auxiliary header for the reason given above. All high-pressure steam and water piping is extra heavy with screwed flanges.

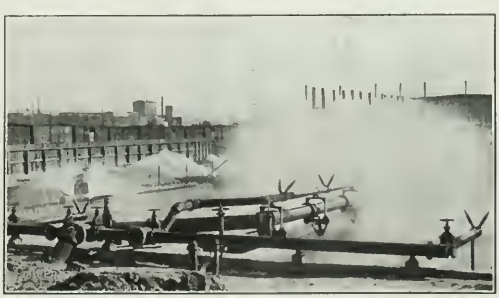


FIG. 7. COOLING BASIN

Feed-water is measured with a venturi meter having two tubes, one 3 in. in size for day operation, the other 1⅝ in. for night use. The indicating and recording part of the meter is located in the engine room conveniently near the engineer's office.

An open type of feed-water heater, rated at 2400 hp., receives the returns from the heating system and the drips from the various steam lines through a 6-in. line. A secondary source of water supply is the discharge from the condenser air pumps and a third source is the city-water mains. A 10 and 11 by 20-in. simplex pump is used for the vacuum of the heating system.

With the exceptions previously mentioned all auxiliary apparatus is supplied with steam from the main header

MECHANICAL EQUIPMENT OF THE POWER PLANT OF THE WEBER WAGON WORKS

No.	Equipment	Tpye	Purpose	Kw.	Volts	R.p.m.	Size	Press.	Hp.	Manufacturers
3	Boilers	Water tube	Steam gen.					150	410	Edge Moor Iron Co.
3	Superheaters	Foster	Sup. steam							Power Specialty Co.
2	Generators	Alt. current	Main units	750	480	3600				Westinghouse Elec. & Mfg. Co.
1	Generator	Alt. current	Main unit	100						
2	Generators	Direct current	Exciters	25	125					
2	Turbines	Horizontal	Main units	750		3600				Westinghouse Mfg. Co.
1	Turbine	Horizontal	Main unit	100						
1	Turbine	Single stage	Exciter unit	25						
3	Condensers	Leblanc	Turbines							
2	Pumps	Knowles	Fire			70	18x10x12″			International Steam Pump Co.
1	Turbine	Single stage	Feed pump			3600		150		DeLaval Steam Turbine Co.
1	Pump	Duplex	Boiler feed				10x6x12″	150		Platt Iron Works
1	Pump	Simplex	Heating system				10x14x20″	150		American Steam Pump Co.
1	Heater	Open	Feed water						2400	Warren Webster & Co.

and the exhaust from all, with the exception of the fire pumps which are piped to the atmosphere, is collected in a 10-in. auxiliary exhaust main which connects with the feed-water heater and the heating main.

Exhaust steam from each main unit is connected with its condenser through a 24-in. pipe, fitted with a hydraulically operated gate valve and with the atmosphere through a 15-in. exhaust stack, and with the 18-in. heating main to the works through a 12-in. pipe. The heating main is also connected with the bleeder on each main turbine through a 12-in. pipe and with the auxiliary-steam header through an 8-in. connection and a reducing and regulating valve.

The 18-in. heating main extends 135 ft. through a 10x7-ft. reinforced-concrete-lined tunnel, and feeds branch lines to the 22 buildings of the works, which contain a total of 60,000 sq.ft. of direct and indirect radiation used for heating, including the drying kilns.

Switchboard and Wiring

The switchboard consists of eight panels of black unpolished slate. Three panels at one end carry the dynamo-controlling and registering instruments. A fourth panel carries a graphic recording and indicating wattmeter and a Tirrill regulator. The other four panels carry the ammeters and nonautomatic, distant-mechanical control oil switches for the various distributing circuits. The direct-current busses are mounted directly behind the board, while the alternating-current busses and oil switches are mounted on pipe racks located beneath the switchboard in the basement.

Eight lead-covered paper-insulated feeder cables of 600,000 circ.mils, running through the tunnel on insulator racks, carry the power current to the various distributing panels in the works; four cables of the same type, but of 300,000 circ.mils, carry the current for the lighting circuits. There are some 10,000 tungsten lamps in the works, ranging in capacity from 25 to 100 watts.

The writer is indebted to Louis Kalm, superintendent of mechanics, for courtesy extended and assistance given in preparing this article.

Device Prevents Sway of Elevator Cables

By William Kavanagh

SYNOPSIS—A description of a simple device to prevent swaying of the cables and the trouble caused by swaying cables in deep elevator shafts.

The hoisting or lifting cables of elevators are likely to leave the grooves of the winding drum from any one of the following causes: First, if the drum unwinds too much; second, if the brake should close on the brake wheel while the car is in rapid motion; third, if the sway or side lash given to the cables is conveyed to the hoisting drum. Any or all of those three reasons will cause the cables either to become loose or ride on the neighboring convolutions, which, of course, will cause more or less trouble. Sometimes a sudden reversal of direction of motion of the car will cause the cables to sway and in numerous cases this sway is caused by a quick stop or start of the car, which may cause the cables to jump out of their grooves. The car must then be stopped to place the cables in the proper grooves.

To do this the try-out or "baby switch" is thrown over for hand operation from the control board and the car is lowered until the cables are unwound and placed in their proper position on the hoisting drum.

When buildings are high or moderately so the swaying of the cables is often a great source of annoyance and when the hoisting mechanism is placed in the cellar or basement of the building, the swaying of the cables is augmented. Owing to their increased length, the cables are more likely to jump out of their grooves. To offset this sway effect the device in Fig. 1 was installed and operated with success.

This sway absorber is placed on the wall of the elevator

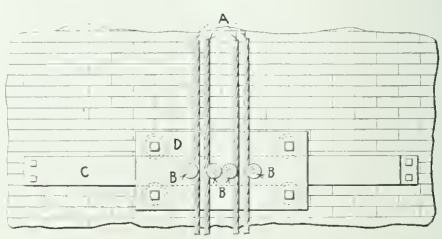


FIG. 1

FIG. 2

Device to Prevent Swaying of Elevator Cables

shaft. The hoisting cables *A* move up and down between the wheels *BBB*. A flat bar of machinery steel *C* is fastened to the shaft wall. On this bar or guide rides the oblong apron *D*, which serves as a frame for the wheels *EE*, Fig. 2, which roll on the bar *C*. The apron wheels

are also shown dotted in Fig. 1. The cable guide-wheels through which the cables move are retained in position by small bolts, which act as axles. These wheels, of course, have curved faces to suit the curvature of the cables and they can be put in place or removed by taking out the axles, which are provided with oil holes for the purpose of lubrication.

The machine is erected in the shaft a distance from the hoisting drum equal to about one-third the height of the building, and it is free to move in a horizontal direction either toward the right or left, thus compensating for the angular or horizontal travel of the cables as they are wound on or off the drum, the machine can be embedded in the wall if necessary or it may stand out from the wall any desired distance.

As the device is built wholly of iron and steel and also being free to move, its weight offers just enough resistance to prevent the cables from swaying appreciably.

Putting New Stems in Corliss Valves

By H. R. Low

SYNOPSIS—The author gives full and comprehensive directions for putting new stems in Corliss valves without disturbing adjustments, although keyways must be located and cut in each valve stem.

The first thing to consider before preparing to mark off the new keyways is the way the T-head on the stem fits the slot in the end of the valve. Should this be too loose a fit, it will not only cause a disagreeable click, but the noise will grow louder as the wear increases, and, besides, lost motion at this point causes a late valve opening. The fitting should be done when the valve and new stem are of the same temperature.

Take off the back bonnet and draw out the valve. Scrape the T-head to a good, snug (not tight) fit. Use a try square from the end of the valve along both sides of the stem to see that it lines up properly, for if it stands off at an angle, it will bind in the gland and bonnet guide, and must be scraped into alignment. It does not require much scraping at this point to make a considerable difference in alignment.

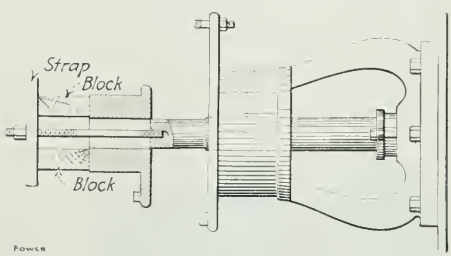
After being satisfied that the stem is parallel with the body of the valve, place the valve back in the port, see that the dashpot plunger is down "solid" on the bottom, and the valve (we are considering the steam valve now) is on the lap. Secure the valve in this position by driving a wedge in between the valve and its chamber. A piece of copper makes an excellent wedge for this purpose. Measure the lap with a pair of dividers to check up with when the job is finished.

The writer is assuming that the reader is aware that underneath the back bonnets, on the face of the valve chambers, and on the end of the valves, are marks or lines which correspond with the opening edges of the valve and port.

Having secured the valve in position, take off the front bonnet and remove the old stem. See if it is numbered or lettered. Whether it is or not, put a good, plain figure on the new stem corresponding to that on the valve. This will lessen the chances of becoming confused should two or more stems be sent to the shop at once. Now try the new stem in the bonnet to see that it fits correctly in the guide, then put the bonnet and stem back in the cylinder in position.

Place the crank on the end of the stem, tapping it lightly or just enough to hold it, taking care that the valve does not move while placing the pin hole in the crank in line with the hole in the end connection of the dashpot rod. When these two holes are in line the crank will be in the correct position and you are ready to mark the keyway. With a sharp-pointed scriber or knife blade mark the keyway in the crank. Take out the stem and with a try square or surface gage carry out the lines the required length on the stem.

These lines can be marked off with great accuracy by placing the stem on centers and using a surface gage from any straight surface. The keyways in the exhaust-valve stems can be laid out from any position of the valve and gear if care is taken to prevent the valve from moving by using the copper wedge, as described above. The gear may be secured by putting a piece of cardboard between



Ready to Force Crank on Corliss Valve Stem

the hub of the wristplate and the washer, setting the nut up firmly. Also see that the check nuts on the reach rods to the wristplate are tight against the end connections to prevent the rods or ends turning. The bonnet and its parts can be assembled complete and the keys fitted while these parts are off the cylinder, thus removing any danger of moving the valve out of its position by pounding or jarring. Should it be desired to assemble the parts with the bonnet in position on the cylinder, the following method of putting on the crank may be used with good results. Drill a hole in the end of the stem, the size of which should be in proportion to the size of the stem and the work it is to do. Assume a stem with the end 1½ in. in diameter where the crank fits.

With a $\frac{7}{16}$-in. drill go deep enough to give a full thread with a ¼-in. pipe tap. Take a piece of cold-rolled steel $\frac{3}{16}$ in. in diameter, and, say, 7 in. long. Taper one end slightly and cut a thread on this end with a ¼-in. pipe die. Thread two-thirds or more of the remaining length with a $\frac{3}{8}$-in. standard die. With two nuts, one checked up hard against the other, this draw bolt can be screwed firmly into the end of the stem.

Start the crank on the stem, using a stick that is just

the width of the keyway to place the keyways in line. Now make a strap of a piece of iron or steel, drill a hole in the center large enough to go over the draw bolt, several washers if large enough in diameter will answer the purpose. Take two or three parallel blocks of hard wood or steel, somewhat larger or wider than the width of the crank and put them between the strap and the face of the crank hub, just clearing the edge of the hole. By screwing up on the nut, the crank should be forced on easily and without leaving a mark. The illustration shows the crank in position and ready to be forced on the stem.

The draw bolt can now be removed from the stem by means of the two nuts locked against each other without injury to the threads. The hole in the end of the stem can be fitted with a plug made by simply cutting a ¼-in. pipe thread on a piece of cold-rolled steel, and sawing a screw-driver slot in it by which it can be screwed into place, and when finished off flush and polished, makes a very neat and much more finished appearance than a center hole.

Results of Tests of Spiro Turbines

By Herbert Coward, M. E.

SYNOPSIS—In testing the turbines a fan dynamometer was used, the fan being run open in the air without housing, thus giving a constant load at a given speed. Results of the tests are indicated by the several curve sheets.

Early in 1912, when the Spiro turbine was first introduced to the public, some performance results were published which became the subject of considerable discussion. The tests on which these figures were based were made non-condensing, or rather condensing at zero vacuum and back pressure, and resulted in a water rate as low as 31.8 lb. per b.hp.-hr. on a 150-hp. turbine.

Since the ordinary types of turbine running under these conditions have water rates from 45 to 55 lb. per b.hp.-hr., these figures were received with considerable scepticism, which caused the manufacturers to undertake an extensive series of tests, not only to verify or disprove the original test results, but to determine the characteristics of the motor under varying conditions of load, speed, etc., so that dependable data might be had to suit the widely varying requirements met with in actual service.

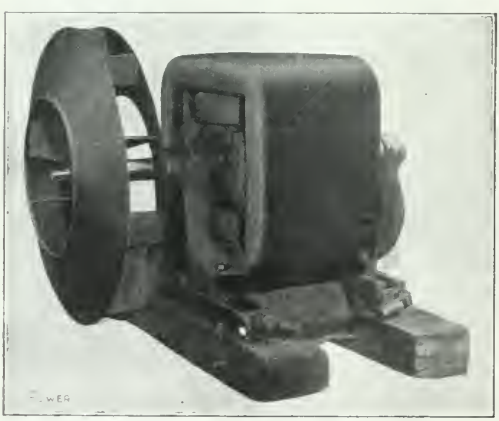


Fig. 1. Fan Dynamometer and Motor

It was arranged with the writer to undertake this series of tests which are now in progress and partial results of which are published in the following. It is the intention to follow the zero back-pressure tests with others at various vacuums, and preliminary vacuum tests indicate very interesting economies. Arrangements are also under way with two prominent universities who will each make independent tests on several sizes of Spiro turbines.

To apply load to these turbines of various sizes in order to secure curves covering a wide range of speed and pressure variables, it was necessary to devise a proper dynamometer. This was done by selecting a number of sizes of air-blast wheels, or fans, with diameters ranging from 8 in. to 4 ft., especially rugged in construction to stand up under heavy absorption.

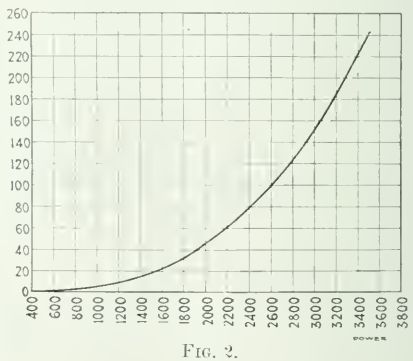


Fig. 2.

In calibrating these so called fan dynamometers, several interesting facts were observed. It may not be known to the majority of readers that a blast wheel run open in the air, as we run these dynamometers, requires from 200 to 260 per cent. more power at a given speed than when in a housing under working conditions. The fact that the load builds up so rapidly in free air and that it is absolutely constant at a given speed, barometric pressure, temperature and humidity, makes the blast-wheel dynamometer ideal for speeds between 1000 and 5000 r.p.m. The correction for barometric pressure, humidity and temperature are direct corrections, involving no guesswork or estimating; on the whole, this type of dynamometer, if carefully calibrated to start with, is more accurate than any other type of absorption dynamometer.

In Fig. 1 is shown a blast-wheel and variable-speed test motor ready for calibration. In order to avoid the possibility of error, the established efficiency of the motor was disregarded, armature current only was read, and the result corrected for no-load current and I^2R loss for each load and speed condition, the resulting figures being the

net total watts input into the wheel necessary to attain each speed.

From these results curves were plotted for each wheel with horsepower as ordinates and r.p.m. as abscissas. One of these curves is reproduced in Fig. 2.

The arrangement for making tests is shown in Fig. 3. Steam is first put through a separator and, after passing

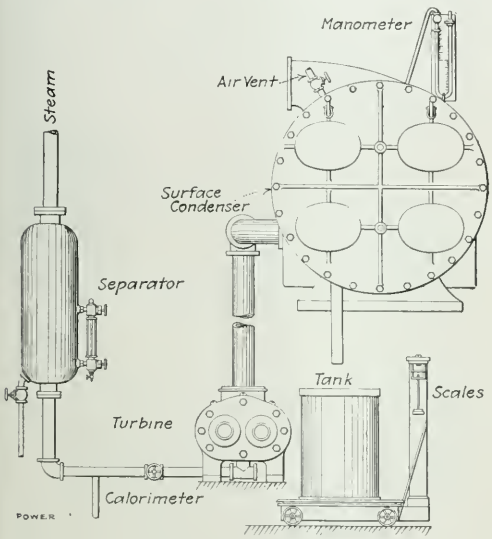


Fig. 3. Spiro Turbine, Condenser and Piping

a calorimeter enters the turbine. From the exhaust it is led to a surface condenser arranged with an air vent to break the vacuum and give atmospheric conditions which were further determined by a U-tube manometer capable of indicating the slightest amount of pressure or vacuum.

The condensate was allowed to flow out of the condenser into a tank mounted on scales.

Over 100 tests are made on each size turbine at varying load, speed and steam pressure. The results of the tests for a 6-hp. turbine at 100 lb. pressure are shown in Figs. 4 and 5, the first being the variation of horsepower with revolutions per minute and the second, the variation of water rate with revolutions per minute and horsepower. It is interesting to note that the absence of loop on either curve indicates that conditions of maximum economy have not as yet been reached. The curve, Fig. 4, shows how the power increases with the speed. As this curve varies but slightly from a straight line, the horsepower approximately varies directly as the speed. The direction and nature of the curve at its highest point indicates that the maximum power has not been reached. In Fig. 5 the curve shows how the steam consumption decreases with an increase of speed. As this curve still has a downward direction at the highest speed it indicates that the point of maximum economy was not reached within the limits of this test.

Curves, Figs. 6 and 7, are for the 100-hp. turbine and show respectively the variation of horsepower with pressure, and the variation of water rate with pressure. Fig. 6 curve shows how the horsepower increases with the steam pressure. One hundred pounds pressure was the maximum available at the place and time of this test, but the nature of the curve indicates that considerable higher

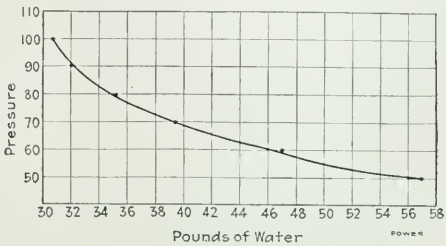


Fig. 7.

pressure could be used. In Fig. 7 the curve shows how the steam consumption decreases with increased steam pressure. As it was seen from Fig. 6 that the maximum pressure has not been reached, still better economy can be expected at the higher pressures.

These examples, taken at random from the tests so far completed, seem to prove conclusively that the Spiro turbine is an exceedingly economical motor.

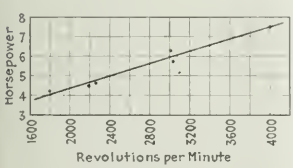


Fig. 4.

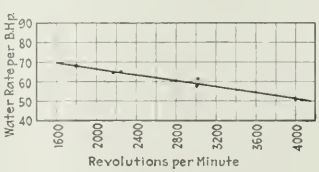


Fig. 5.

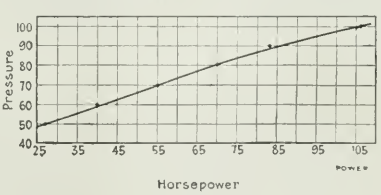


Fig. 6.

There is being built at Beldens, Vt., for the Vermont Marble Co., of Proctor, a new power plant, for furnishing electric power to the quarries in the neighborhood of Proctor, 40 miles away. There are to be two units of 1200 hp. each, directly connected to 800-kw. Westinghouse generators and running at 300 r.p.m. Each unit is a 1200-hp. double turbine manufactured by the S. Morgan Smith Co., York, Penn., the turbines having runners 33 in. in diameter, on a horizontal shaft, and the flow of water being controlled by the familiar wicket-gate system. The discharge from the turbines runs through a draft tube 16 ft. in depth.

This plant is practically a duplicate of a plant built in 1910 at Huntingdon Falls, about two miles from Beldens. Both plants will operate over the same set of transmission lines at high voltage, all of the power being used in the neighborhood of Proctor.

The University of Cincinnati shortly after the flood detailed Prof. A. Wilson and six senior students of the electrical course to go to Hamilton, Ohio, and assist in the rehabilitation of the power plant and water-works. The students rendered valuable assistance in getting both systems in operation again within the week.

Nordberg Long-Range Valve-Gear

SYNOPSIS—This valve-gear is designed to give a long-range cutoff without the customary two eccentrics. The mechanism of the governor and the cutoff gear, which is operated by a separate eccentric, makes this possible. A valve-gear of different design is used on engines running at a speed of 150 r.p.m. or more.

The Nordberg, long-range, valve-gear, Fig. 1, secures a long range of cutoff without the aid of a double-eccentric gear. The arrangement of drop arm, valve arm and hook are essentially the same as in the Nordberg standard gear. There is, however, a difference in that the hook D is positively thrown in and out of engagement with the drop arm H by means of a lever G, which terminates, through a roller R, in an oscillating cam E. This cam is hung on an extension C of the valve arm ABC and has two concentric circular slots whose center is the point of suspension of the cam. The two circular slots are joined by a transition slot. When the roller passes from one slot to the other, the hook is released or engaged. No relative motion between the cam and roller is produced by the motion of the wristplate, that is, with the engine standing still and the wristplate rocked through its entire range, the trip steels remain stationary relative to each other.

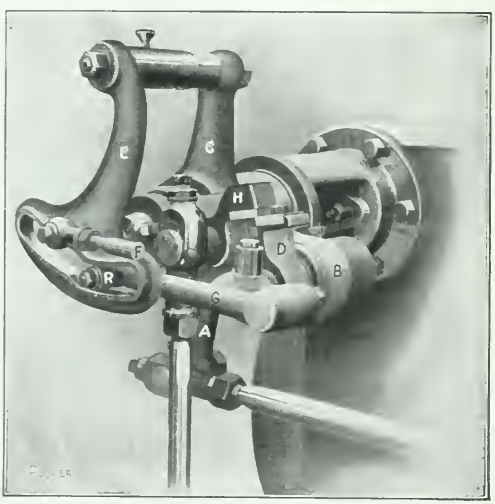


FIG. 1. NORDBERG LONG-RANGE VALVE-GEAR

The cam E is oscillated about its point of support through a cutoff rod F, which receives its motion from a separate eccentric, the throw of which corresponds approximately to the length of each of the circular slots. If the engine is running below normal speed and the governor is resting on the collar, the roller remains in the lower slot, the hook steels remain in contact and steam is admitted the full stroke of the piston. With the engine at normal speed and no load, the governor is in its highest position and the roller remains in the upper slot of the cam, the trip steels remain disengaged and no steam is admitted to the cylinder. The cutoff takes place coincident with all the intermediate positions taken by the governor, which changes the center of oscillation of the cams, between the two extreme limits described.

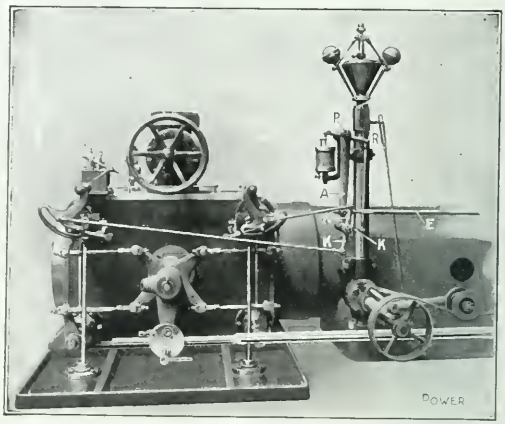


FIG. 2. LONG-RANGE VALVE-GEAR AND GOVERNOR

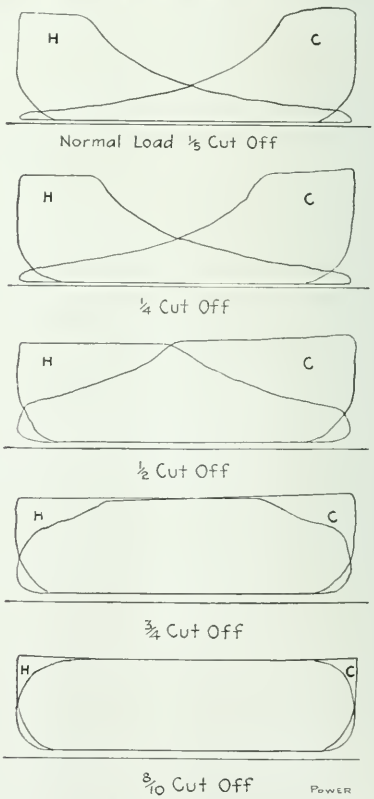


FIG. 3. DIAGRAMS SHOWING VARYING CUTOFF

The center of oscillation of the cams is controlled by the governor in such a manner as to free it from any reaction due to movement of the knock-off eccentric. For this purpose the motion of the governor and eccentric is transmitted to the cams through the mechanism illus-

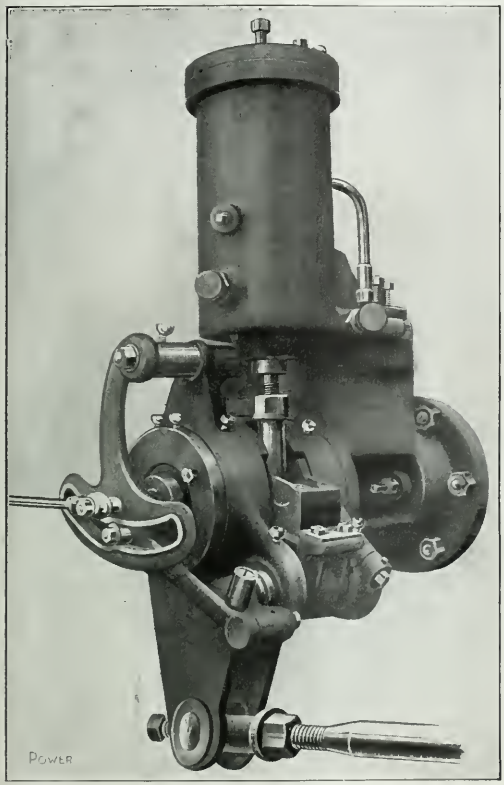


FIG. 4. NORDBERG HIGH-SPEED VALVE-GEAR

trated by Fig. 2. This consists of a parallelogram whose main lever is supported by a bracket on the governor, free to swing about the point P, and which is driven by the knock-off eccentric rod E. At the bottom end of this lever is hung the three-armed lever K, the two vertical ends of this lever being connected to the knock-off cams and the horizontal arm connected by a rod parallel to the main lever A, the upper end of which is connected to the governor at the point R.

As this parallelogram is oscillated by the knock-off eccentric-drive rod, its sides remain parallel, therefore, the lever K always moves in a position parallel to itself. Should a change of load occur, the governor lifts or lowers the point R, thus changing the angularity of the lever K and changing the center of oscillation of the cams and the point of cutoff.

Fig. 3 shows five cards from a Nordberg Corliss engine, fitted with long-range gear, manufactured by the Nordberg Manufacturing Co., Milwaukee, Wis. These cards show the wide range of cutoff obtained under full control of the governor. At normal load the cutoff is at $\frac{1}{4}$, and this is increased up to 0.8 cutoff with 200 per cent. of the normal load. This feature enables an engine to carry high overloads, and to take care of sudden peak loads without impairing regulation. Again, it permits an engine to carry heavy loads with the steam pressure below normal.

The gear shown in Fig. 2 is well adapted for high speed of rotation, because engagement and release of the trip steels is positive and effected without the aid of springs or gravity. But for engines which are to run at very high speeds, that is, 150 revolutions or more, the type of gear illustrated in Fig. 4 is used. The essential difference between this and the gear for ordinary speeds is that it is symmetrical with respect to a central plane, there being no overhung parts, with the exception of the full-stroke cam. Therefore, there are no bending strains which, at high speeds, become serious in a valve-gear of the overhung type. The valve stem has two bearings in the bonnet outside of the stuffing-box, and the drop arm is keyed to the stem between these two bearings. The end thrust of the stem is taken up by a hardened-steel plate located in the bonnet cap, instead of by a collar.

The bearing surfaces are several times larger than those on the ordinary gear, which reduces wear. The valve-gear has small travel and to secure positive and sharp action, spring dashpots are used, as shown.

In order that the valve-gear may have small travel and at the same time give ample port area, the valves used on

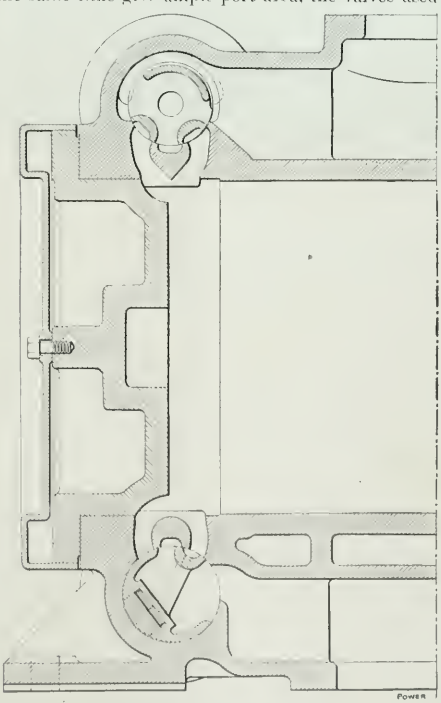


FIG. 5. FOUR-PORTED VALVE

engines equipped with this gear are of the Nordberg four-ported type, illustrated by Fig. 5. The combination of this high-speed gear eliminates lost motion, and as the cutoff is controlled by a separate knock-off eccentric, close regulation is secured.

When the exhaust valve is closed, the valve cavity is not thrown into the clearance. It is essential to have small clearance in engines of this type, because with high rotative speed the stroke must be shortened to keep the piston speed within reasonable limits.

Pump Working under Water

By W. S. Standiford

During the recent flood at Youngstown, Ohio, there was one industry, Renners Brewery, that worked continuously throughout the flood period. The pumping station of the brewery, located on the bank of the Mahoning River, was the object of much comment. As the water kept rising, an extension was put on the exhaust pipe of the pump

Pump Operating Submerged under 3 Ft. of Water

to prevent the pipe and pump from flooding, thus forcing a suspension of the plant's operation.

The water completely submerged the building and rose to within 6 in. of the top of the pipe, with 6 ft. of water over the pump. The illustration shows the pump working under 3 ft. of water. As the water receded, an employee crawled out over the pipe line and decorated the pump house with the "Stars and Stripes," in recognition of the services the machine had rendered. The pump house, a substantial structure, withstood the torrent that carried many another building down stream.

Thread-Tight Pipe Compound

A pipe-joint compound which has the approval of engineers is known as "Thread-Tight." This paste has been compounded with the purpose of making threaded joints tight and to not harden after being subjected to the influences of either heat or cold and consequently permit of joints being unscrewed with but little effort.

This paste compound will adhere equally as well to wet as to dry threads; an important thing in the process of repair work. It is also for use on flange joints, being applied in connection with a gasket of thin paper, which is used merely as a means of holding the paste in place until the two flange faces are brought together.

Regarding its adaptability in preventing leakage in screwed joints, one user of the compound states that it was used on a threaded pipe joint made hand tight, no pipe wrench being used, and the joint tested at 350 lb. hydraulic pressure without showing leakage and with a similar result with a steam pressure at 110 lb.

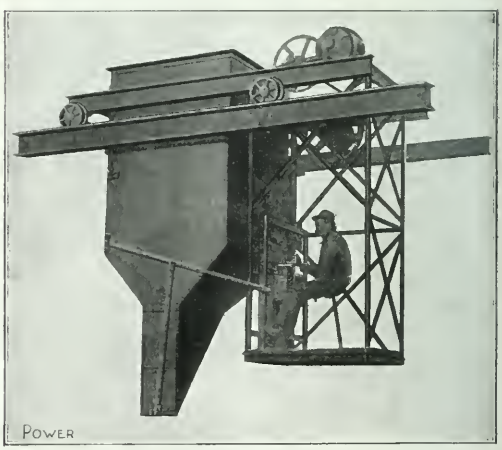
This thread paste is made by the Thread-Tight Co., U. S. Express Bldg., 2 Rector St., New York City.

Motor-Driven Coal Hopper

Motor-driven coal hoppers, which can take coal from bunkers located anywhere and deliver it to any boiler in a battery, are coming into favor. Their use does away with the system of overhead bunkers and individual chutes for each boiler, and permits all the coal to be concentrated in one bunker instead of in a series of pockets.

The bunkers can be placed at one end of the boiler room, or, for that matter, outside if necessary, so that the boiler room can be designed and located with greater freedom, and plenty of space left above the boilers for light and air.

The hopper, as shown, runs on a trackway parallel to the front of the boilers and is controlled by an operator in the same manner as an overhead crane. Accurate



Motor-Operated Coal Hopper

scales on the hopper make it possible to keep a precise record of the fuel burned by any boiler. If desired, a recording device can be installed so that a printed record of the weight of every discharge can be made by the operator. The hopper runs under the bunker and is filled by the operator, the scales indicating when the hopper is full. It is then run into the boiler room and delivers the coal where wanted.

This hopper is manufactured by the Bergen Point Iron Works, Bayonne, N. J.

The Toronto Hydro-electric Light and Power Comission has just issued its report of operations for the past year. The gross income amounted to $726,763.55; the cost of generating power, including maintenance, repairs and management was $500,564.26 and interest, sinking fund and depreciation amounted to $212,643.38. This leaves a net surplus of $13,555.91, an excellent showing when it is considered that the commission is just embarking upon its third year of operation

ELECTRICAL DEPARTMENT

Primer of Electricity

A lap-connected winding may be connected to the commutator in either of two ways, commonly termed "right-handed" and "left-handed." A right-handed winding is one that progresses to the right, tracing through each coil from its left-side terminal to its right-side terminal; Fig. 166 illustrates this definition. Here are represented four single-turn coils, *A*, *B*, *C* and *D*, connected to commutator bars right-handedly. Starting at the left-side terminal *a* of the coil *A* and tracing through that coil and the adjacent ones leads the tracer to successive coils and commutator bars to the right of the coil *A* and bar 1. Fig. 167 illustrates the left-handed winding; the progression from coil to coil and bar to bar being to the left of the starting point. In both cases the start is made at the left-side terminal of the first coil (*A*) and the path through each coil is "clockwise."

The following rules are fundamental for simple lap-connected drum windings:

1. The terminals of each coil of the winding must be connected to adjacent commutator bars.

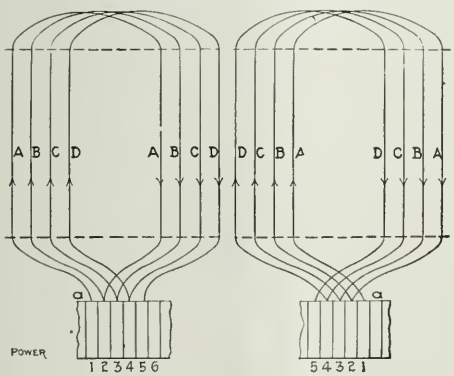


Fig. 166. Part of a Right-Handed Drum Winding
Fig. 167. Part of a Left-Handed Drum Winding

2. The left-side terminal of every coil must be connected to the same commutator bar with the right-side terminal of the coil next to it in "commutator sequence."

3. In a right-handed winding the right-side terminal of each coil is connected to the same commutator bar as the left-side terminal of the coil next in commutator sequence to the *right* of it. (To the right means in the clockwise direction around the core, facing the commutator.) See Fig. 168, where the right-side terminal of the coil *AA'* is connected to the same bar as the left-side terminal of the coil *BB'*, which is next to the right of it in commutator sequence.

4. In a left-handed winding the right-side terminal of each coil is connected to the same commutator bar as the left-side terminal of the coil next to the *left* of it in commutator sequence. See Fig. 169, where the right-side terminal of the coil *AA'* is connected to the same bar as the left-side terminal of the coil *BB'*, which is next to the left of it in commutator sequence.

"Commutator sequence" is the sequence in which coils are connected to the commutator. Referring to Fig. 170, for example, the coil *B* is next to the coil *A* in commutator sequence because its left-side terminal is connected to the commutator bar next to the one to which the left-side terminal of the coil *A* is connected. The coil side lying between the sides of the coils *A* and *B* is of the opposite

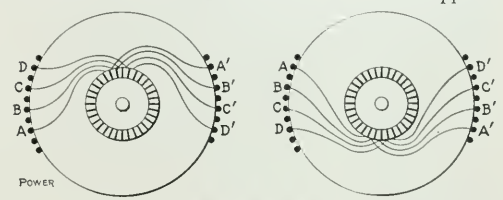


Fig. 168. Preferred Arrangement of Right-Handed Coil Terminals
Fig. 169. Preferred Arrangement of Left-Handed Coil Terminals

"hand"; that is, the coil side between the left sides of the coils *A* and *B* is a *right* side, and the coil side between the right sides *A'* and *B'* is a *left* side. Their terminals lead away from those of the coils *AA'* and *BB'*, as indicated by the dotted lines.

In order to produce the smallest number of overlappings between the terminals leading from the armature to the commutator of a bipolar machine, the terminals in a right-handed winding must be led to bars in the upper half of the commutator (the coil being in a substantially horizontal plane); the reverse is true for a left-handed

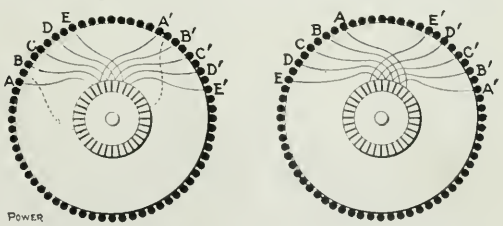


Fig. 170. Right-Handed Connections for Four Poles
Fig. 171. Left-Handed Connections for Four Poles

winding. Figs. 168 and 169 illustrate these conditions. If the winding in Fig. 168 were connected left-handedly, the terminals of each coil would cross each other between the armature and the commutator, because the right-side terminal of coil *CC'* would have to be connected to the same bar with the left-side terminal of coil *BB'*, and so on. This would be true also of Fig. 169 if the connections were changed to right-handed.

In all multipolar machines, the winding must be of the right-handed type to avoid having the terminals of each coil cross each other. Figs. 170 and 171 illustrate this; in the former, representing a right-hand winding, the

terminals of any one coil do not cross each other, whereas in Fig. 171, representing a left-handed winding, the terminals of every coil cross each other. These windings are for an armature to work with a four-pole field magnet.

A dynamo or motor will operate just as well with a left-handed as with a right-handed winding, but either the brush polarities or the direction of rotation will be reversed. Fig. 172, for example, shows the correct brush polarities for clockwise armature rotation with a right-handed winding connected as shown in Fig. 168; if the winding were connected left-handedly, the brush A would be positive and the brush B negative, and the connections between the brushes and the field winding would have to be reversed in order to maintain the same field polarity; or else the direction of rotation would have to be reversed in order to keep the brush polarity unchanged.

The brush position here represented is correct for a

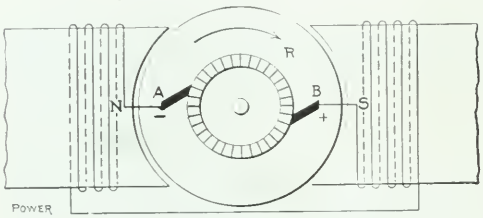


FIG. 172. BRUSH POSITIONS AND POLARITIES WITH SYMMETRICAL COIL LEADS

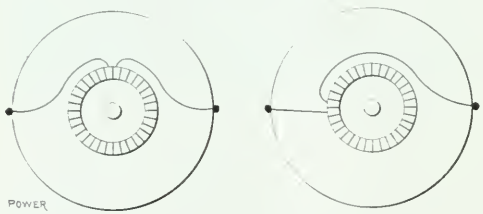


FIG. 173. SYMMETRICAL COIL LEADS

FIG. 174. EXTREME BACKWARD UNSYMMETRICAL LEADS

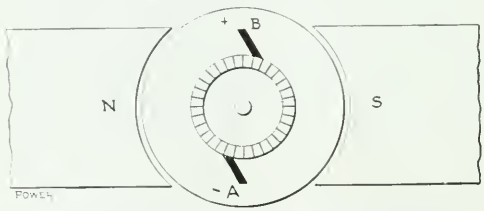


FIG. 175. BRUSH POSITIONS AND POLARITIES WITH EXTREME BACKWARD UNSYMMETRICAL LEADS

winding in which the two leads or terminals of each coil are of equal lengths, as illustrated in Fig. 173. If the left-side lead were brought straight out from the left side to the commutator, parallel with the armature shaft, the right-side terminal would have to extend almost across the armature head to reach the proper commutator bar, and the two bars corresponding to any one coil would be almost in line with the left side of the coil, as in Fig. 174. Consequently, the brushes would have to be located as shown in Fig. 175. The effect is as though the coils had been connected symmetrically, and the commutator twisted backward nearly 90 deg., making it necessary to shift the brush position backward to the same extent.

Changing from Sixty to Twenty-five Cycles

In a plant using alternating current at 60 cycles it was recently necessary to have available current at a frequency of 25 cycles. The infrequent demand for it and the small quantity required did not warrant the purchase of a machine for that purpose so it was decided to obtain it from a 60-cycle apparatus on hand.

A three-phase, 15-kw., 115-volt, 60-cycle, 6-pole, revolving-field alternator with direct-connected exciter was pressed into use for this service. To produce a frequency of 25 cycles the speed was reduced from 1200 to 500 r.p.m. As the field of the exciter was designed for 125-volt excitation, it was impossible to build up the field to normal strength with the direct-connected exciter, due to

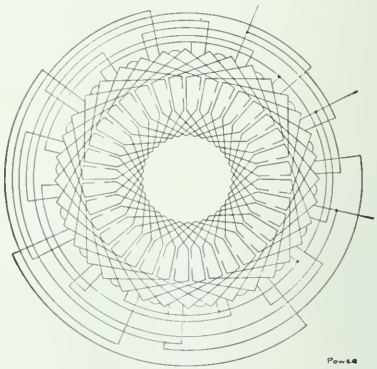


FIG. 1. PARALLEL-STAR WINDING

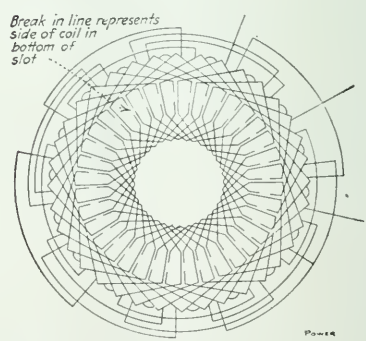


FIG. 2. SERIES-STAR WINDING

the reduction in speed. The brushes were therefore removed from the commutator of the exciter and the two slip rings were connected to a 110-volt, direct-current supply circuit with the rheostat in series. This arrangement gave about 50 volts alternating current across any two of the three leads of the generator, which was too low for the purpose. An examination of the alternator armature showed the windings to be connected parallel-star, as in Fig. 1; this was changed to series-star, as in Fig. 2, doubling the number of turns in series and consequently the voltage. Cutting out resistance with the rheostat easily raised the voltage to 120 volts, which was ample for the purpose for which it was required.

GAS POWER DEPARTMENT

The Illmer Two-Stroke-Cycle Gas Engine

The first gas engine of American origin to employ the double-acting, two-stroke cycle has recently been put out by the Reading Iron Co. from the designs of Louis Illmer, Jr., who has devoted the past eight years toward perfecting this product.

The engine is of the slow-speed type, designed for heavy-duty service along the lines of steam-engine practice, and the aim throughout has been to reduce to a minimum the number of working parts, the theory being that a multiplicity of working parts greatly increases the liability to shutdown. In carrying out this idea a number of unusual features have been embodied.

In the first place, all previous applications of the double-acting, two-stroke cycle have employed separate air and gas pumps. In the Illmer engine, however, this work is accomplished by a single pump of the double-acting type, the stratification principle being employed in scavenging and in the admission of the charge.

A second mark of individuality is the valve gear, which is a distinct departure from usual practice. This is positively actuated by means of an eccentric drive, the inlet valves being opened and closed by a double-toggle linkage, as shown in Fig. 1; there is a total absence of springs, except for the small ones on the igniters. In this way properly accelerated and retarded movements are imparted to the valves and cause them to seat gently, the valves being pressed on their seats by a slight springing of the rocker shaft. Provision is made for independent adjustment by having all the link pins bronze bushed and the links provided with keepers to allow for wear. The pump valves are actuated direct from the wristplate.

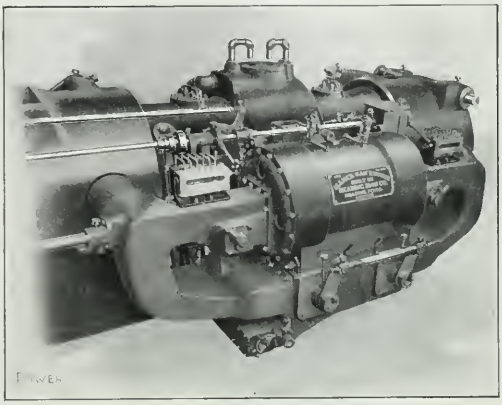


Fig. 2. Pump Side of Cylinder

As the engine is of the two-stroke-cycle type, there are, of course, no exhaust valves.

The inlet valves are of the annular poppet type, coaxial with the cylinder, and that on the crank end surrounds the piston rod (see Fig. 3). They slide in housings, and suitable packing is provided. This arrangement permits a large inlet port opening into the power cylinder (about 25 per cent. of the piston area) and thus tends to reduce the pump work, which is said not to exceed 5 per cent. of the indicated power of the engine.

Replaceable liner sections are fitted to the power cylinder, and the exhaust ports, drilled into the inner liner ends, are surrounded by an annular exhaust chamber cast

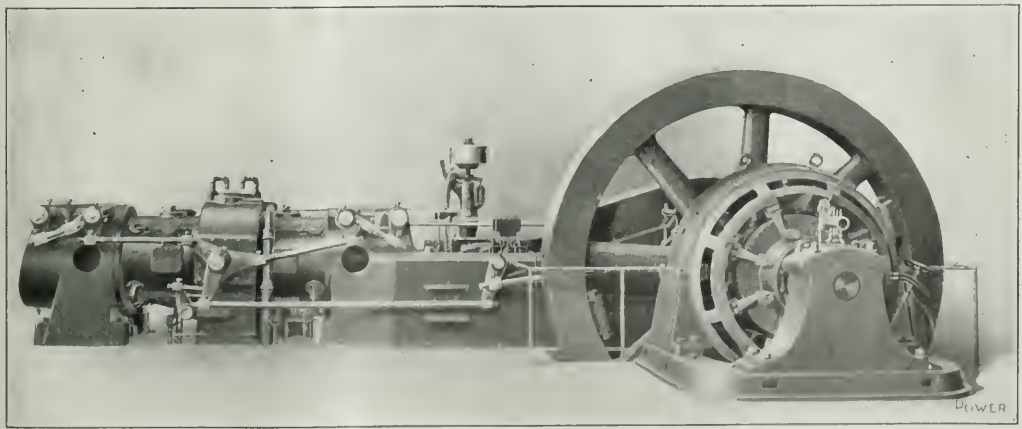


Fig. 1. View of Engine, Showing Valve-Gear

integral with the cylinder. A handhole in the exhaust chamber admits of cleaning the exhaust ports and also provides a means for inspecting the piston rings.

The engine is of the side-crank type, a drag crank being provided for driving the pump piston and the governor.

Pump Details

Fig. 2 is a view of the cylinder from the pump side, and Fig. 3 is a section through the power cylinder, inlet valves, pump cylinder and ducts representing that position in which the air and gas are being drawn into the pump on the head end (right) and the charge forced into the working cylinder on the crank end (left).

Following through the pump cycle, first consider only the head end with the pump piston just beginning its travel toward the left. The valve V would then be rotaton has just passed midtravel on the suction stroke, are indicated in the sketch (head end).

By the time the pump piston has reached the end of its stroke, the valve V will have rotated in a clockwise direction so as to close ports A and D and start to open port E. During the first part of the return or discharge stroke the charge is compressed slightly. Just previous to the pump piston reaching midstroke the power piston uncovers the exhaust ports and simultaneously the inlet valve opens.

Port E is now entirely uncovered and a free passage is established between the pump cylinder and the lower end of duct F. Hence part of the air is forced through ports B and E, pushing the column of gas ahead of it and at the same time the rest of the air is forced through passage G, around F, and meets the gas at the mixing ports H.

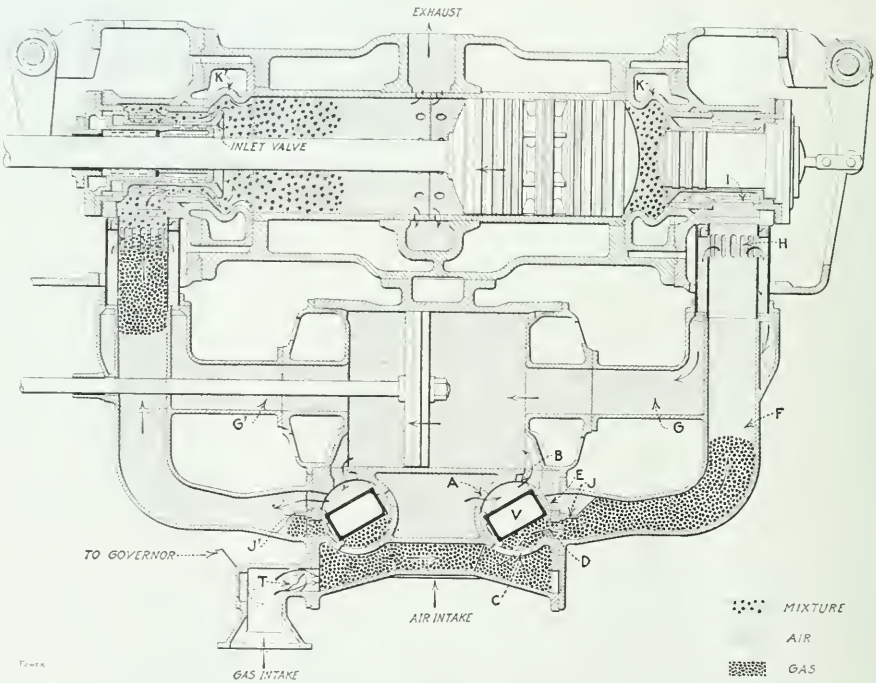


Fig. 3. Section through Cylinder and Pump, Illustrating Stratification of Charge

ing counter-clockwise, so as to uncover the ports A and D; B and C already being open. This permits air to be sucked through A and B; also, residual air from the previous charge, which has remained in the upper part of duct F, is drawn into the pump cylinder through passage G. The latter creates a suction in duct F, and draws in gas through ports C and D, the height to which the gas rises in F depending upon the governor, which controls the throttle valve T. The air lying behind the inlet valve in the pocket I is not displaced by the suction of the pump, but remains in this position during the entire period of inlet closure to be introduced into the power cylinder as scavenging air ahead of the next charge. The relative positions of the air and gas when the pump pis-

The residual air in the pocket I and any air ahead of the body of gas will have been forced ahead of the mixture to scavenge the cylinder of burnt gases. The crank-end view of Fig. 3 represents the position taken by the mixture charge at the instant of entering the power cylinder.

When the inlet valve closes, the mixture will have been forced into the power cylinder and the air lying behind it serves as scavenging air for the next charge.

A bypass (not shown) connects the two ends of the pump. By setting the valve in this the air may be so regulated as to control the position of the mixture within the power cylinder.

The air-check valve (not shown) in the passages G and

G' opens inward, so as to provide a free passage of air toward the pump. On the discharge stroke of the pump the check closes and the air has to pass around the valve, the opening being made adjustable by the setting of a lever. Accordingly a relatively large body of gas may be sucked into the duct F without being affected perceptibly by any throttling adjustment made for the air discharge through the connections G or G', whereby to adjust the ratio of air to gas in the mixture charge.

The purpose of the walls J and J is to form pockets, which cause the air to eddy and spread before discharging into the neck of the ducts.

An important feature of the power-cylinder design are the lugs of baffles K and K'. The charge enters the cylinder in the form of a hollow cone around the inlet valve, and strikes the baffle K or K' approximately normal to its direction of flow. This causes the mixture to whirl

Fig. 4. Power-Indicator Diagrams from Cylinder

and lose much of its velocity spreading over the cylinder and driving out the scavenging air.

Proper spreading of the charge is largely facilitated by a new principle embodied in the cylinder-head construction, namely, the turning of the working charge and imparting to it a direction of flow parallel to the power cylinder axis before discharging it through the inlet port.

The engine shown in the illustration is rated at 300 hp., and has for some time been carrying the entire shop load of the Scott Foundry Department of the Reading Iron Co. It operates on producer gas. A similar one of 500 hp. is nearing completion.

Fig. 4 is a reproduction of an indicator diagram

Fig. 5. Indicator Diagram from Pump

taken under operating conditions, and Fig. 5 shows an indicator diagram taken from the pump.

Test of Engine

In the following table are given the results of a 33½-hr. full-load test on this engine:

TEST OF 300 HP. ILLMER GAS ENGINE

Duration of test, hr.	33¼
Grade of coal. Westmoreland bituminous @ 14,100 B.t.u. per lb. as used	
Character of load.	Water rheostat
Average load registered on calibrated recording ammeter, amp.	774
Average voltage (corrected)	253
Average developed load, kw.	196
Average developed load, B.hp.	284
Power required for auxiliaries, kw.	11
Power required for auxiliaries, B.hp.	16
COAL BURNED	
Fed to hopper, lb.*	10,352
Equivalent required for steam jet blower, lb.	502
Total coal used in 33¼ hr., lb.	10,854
Cold cleaned gas measured in holder, feet per pound of total coal used.	65.4

ANALYSIS OF GAS

CO_2	2 91 per cent. by volume
O_2	0 2 per cent. by volume
C_2H_4	0 7 per cent. by volume
CO	27 51 per cent. by volume
H_2	6 52 per cent. by volume
CH_4	2 24 per cent. by volume

Average B.t.u. of gas by calorimeter (35 determinations corrected for holder temperature, and pressure) B.t.u. per ft. higher	144
Average B.t.u. of gas by calorimeter (35 determinations corrected for holder temperature, and pressure) B.t.u. per ft. lower	138
Producer efficiency on basis of cold cleaned gas and total coal used, per cent. on higher B.t.u. of gas	67
Producer efficiency on basis of cold cleaned gas and total coal used, per cent. on lower B.t.u. of gas	64
Thermal efficiency of engine, lower B.t.u. per b.hp.-hr.	10,300
Total coal used per developed b.hp.-hr., lb.	1.14
Total coal used per developed kw.-hr., lb.	1.65
Total coal used per b.hp.-hr., delivered for use, lb.	1.21
Total coal used per kw.-hr., delivered for use, lb.	1.75

The instruments on which the results were obtained have been checked with the General Electric standards, and it was found that the instruments read a little low; hence the revised results are even more favorable than the original figures.

⁂

Rubbish as Fuel

Different waste materials have different heating values, the combustible value of some of them, such as shavings and turnings of wood-working establishments, spent tan bark of tanneries, etc., being so high that they are used by many manufacturing establishments as the principal fuel for generation of steam. It does not pay, however, to burn these materials or trash along with coal. The ash of the more highly combustible substances contained in the waste material becomes mixed with the coal and hinders or almost entirely prevents combustion of the coal and much of the latter is slowly coked off in incomplete combustion or drops through the grates. There is fuel economy in burning waste material exclusively, provided its combustion yields sufficient heat to keep up steam, but where the main fuel is coal, rubbish or other waste material should not be burned in a boiler furnace, excepting at the end of a run or just prior to cleaning of fires.

Even then it may not pay if the use of waste material is attended by such imperfect combustion as to produce excessive deposits of soot on the heating surfaces of the boiler, thereby reducing the efficiency of the heating surfaces and the evaporative economy when firing the coal required. The effect which waste material has on a boiler depends entirely on the character of the combustible. Highly combustible material like yellow-pine chips or shavings, by local impingement of intense flame when used as fuels, are likely to burn or blister a boiler, especially such portions of the heating surface as are not cooled by rapid circulation of water in the boiler, while waste material which contains much moisture causes a rapid rusting out of sheet-iron or sheet-steel smoke breechings, uptakes and smoke-stacks.

In addition to the objection referred to, in making use of waste material as fuel, the fact should be borne in mind that moist or wet fuels of almost any kind are more rapidly destructive of firebrick furnaces than dry fuels.

⁂

The Southwark Foundry & Machine Co., Philadelphia, Penn., is making three 3000-kw. Rateau turbine-driven alternators for the Pittsburgh Steel Co. It also recently shipped a 1500-kw. unit to the Goodyear Tire & Rubber Co., Akron, Ohio, and another unit to the Reading-Massachusts Rubber Co., all of the mixed-flow type. The company has also built five turbo-driven rotary blowers, of which three are in operation. These have a maximum capacity of 50,000 cu.ft. of free air per minute, and a maximum blast of 30 lb.

REFRIGERATION DEPARTMENT

Cooling Tower for Small Refrigerating Plant

By R. L. Mossman

The accompanying drawings illustrate a cooling tower built by the writer for cooling the water from the ammonia condenser in a small refrigerating plant of 8- to 10-ton capacity. The condenser is of the double-pipe type, with 1¼- and 2-in. pipes, 19 ft. long and 12 pipes high. The tower consists of four stands of 20 strips each, the strips being 1½ in. square, rounded on top and 16 ft. long. They are spaced on 5-in. centers and supported by notched pieces of 2x4-in. timbers, as shown in the drawings. Fig. 2 is a detail drawing of the trough and strips. The trough, which is supported by the 2x4-in. uprights, distributes the water at the top of each stand.

The tower rests on a floor of tongue and grooved boards supported by 2x12-in. joists and a frame of 6x6-in. timbers, as shown in Fig. 1. The floor slopes toward the trough, the drop being about 3 in., and the trough itself slopes toward the tank, as shown in Fig. 1. A piece of 1½-in. pipe is secured to the bottom of the trough with locknuts and discharges to the tank. The suction to the circulating pump is connected to the bottom of the tank and the warm water from the condenser is piped to the troughs on top of the tower. It may be noticed in Fig. 1 that the tank is equipped with a float valve controlling the city water supply. Due to evaporation and other losses some make-up water is required.

The tower was built without the louver around it, but in high winds there was considerable loss of water, and the louver shown in the drawings was added. Contrary to the usual custom the slats are turned up to catch and drain back any water which may be thrown against them.

With a temperature of the atmosphere of 65 deg., the humidity not being known, water supplied to the tower at 80 deg. F. was returned at 65 deg.; about 19 or 20 gal. of water was circulated per minute. The high-pressure ammonia gage showed 150 to 155 lb. The compressor was a 6½x6½-in. double-cylinder, single-acting, vertical machine running at 150 r.p.m.

The writer knows of a tower of this type with strips 16 ft. long and 20 strips high with but two stands. This gave a total of 640 linear feet of strips which were claimed to cool the water for an 8-ton plant from 100 to 80 or 85 deg. In my opinion three stands would be sufficient for an 8- or 10-ton machine.

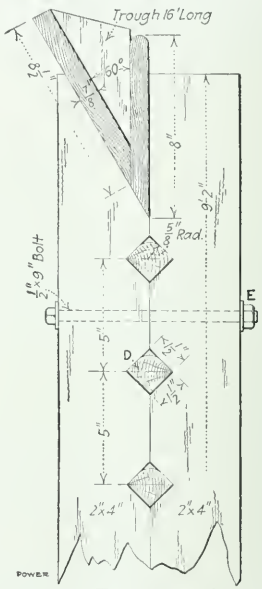


Fig. 2. Details of Trough and Top of Stand

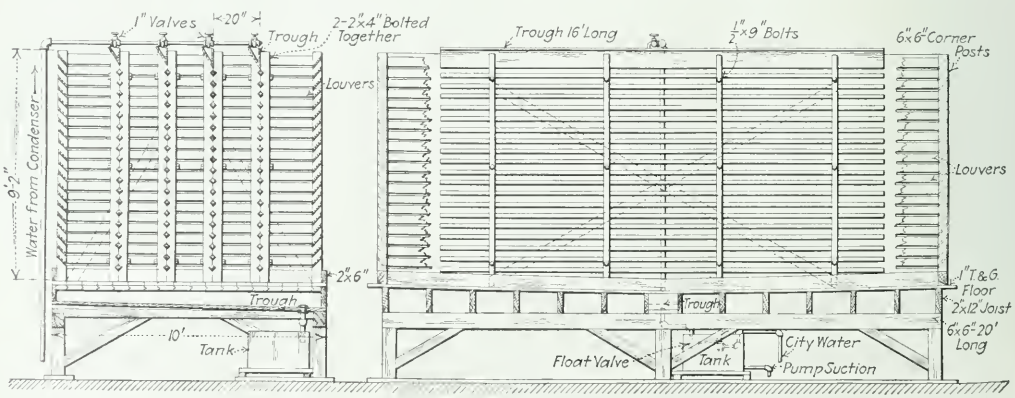


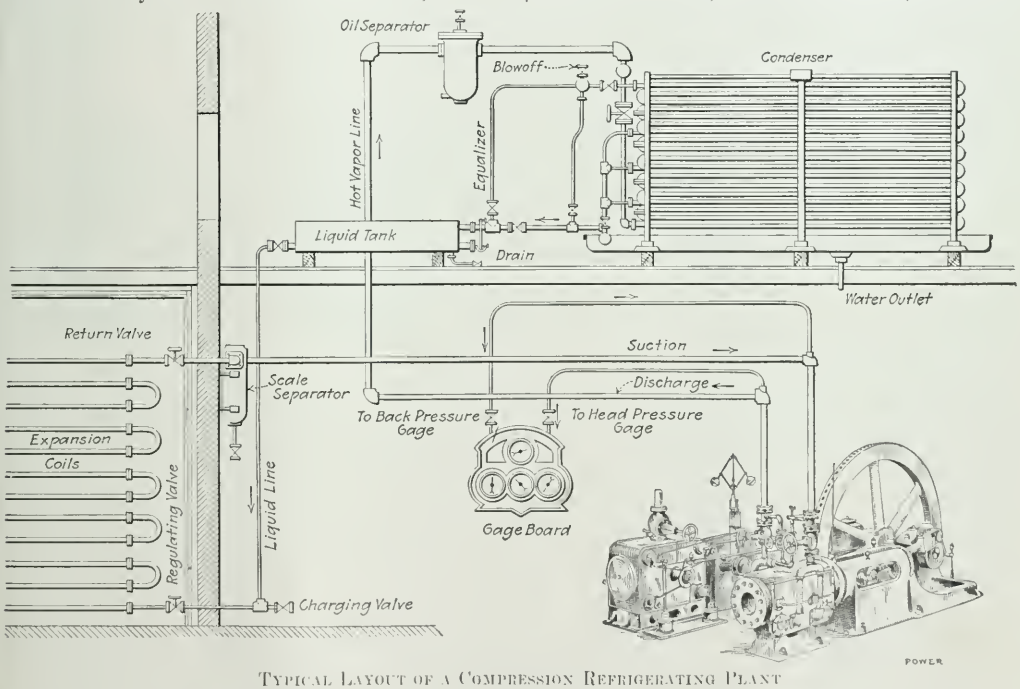
Fig. 1. Transverse Section through Tower and Side Elevation

The Compression System

In the Mar. 11 number of POWER an elementary description of the ammonia-compression system was given and a simple diagram showed how refrigeration was accomplished. The four fundamental parts of a compression plant and their relation to each other were shown in diagrammatic form. As will be remembered, these fundamentals were a compressor to draw the cold vapor from the expansion coils, compress it to a high pressure and discharge it; the condenser where the high-pressure vapor from the compressor is liquified; the regulating valve (more commonly but erroneously called the expansion valve) which reduces the pressure of the liquid from the condenser, and the expansion coils in which the liquid is changed into a vapor by absorbing heat from the room or brine tank in which the coils are located. In one form or another these four sections are always present and to these are usually added a number of auxiliaries, such as a liquid tank, to receive the ammonia from the condenser, scale and oil separators, pumps for forcing the oil to the cylinder or perhaps the bearings, and a couple of gages to show the pressures in the suction and discharge lines of the compressor.

Naturally there is considerable difference in the construction of the different apparatus employed. The compressor may be horizontal or vertical, single-acting like the usual small gas engine or double-acting like the steam engine. The condenser may consist of a series of pipes or coils submerged in water, it may be of the atmospheric type in which the pipes are exposed to the air with a thin stream of water trickling down over their surface, or a double-pipe counter-current condenser in which the ammonia in the inner pipe flows in a direction opposite to the water in the outer pipe may be used. There are different kinds of regulating valves and the arrangement of the expansion coils may vary.

It is not necessary to use a particular type of condenser with a certain design of compressor. Each has its own work to perform, and its efficiency does not depend primarily on the other. The same is true in a power plant. The boiler may be of the fire-tube or water-tube type and if steam of the proper quality and pressure is supplied the engine, its economy will not be effected. As long as there is plenty of surface for the conduction of heat in the refrigerator and condenser, pipes of sufficient size for the vapor to pass without friction and an easy passage for the liquid ammonia, types do not count. The accompanying illustration, then, may be used to show the general requirements of a commercial plant. The high-pressure end of the system, consisting mainly of the compressor and condenser, is shown in full detail, but the low-pressure side (expansion coils) is merely indicated, as there will be some variation in every installation.



TYPICAL LAYOUT OF A COMPRESSION REFRIGERATING PLANT

We will begin with the liquid ammonia which is stored in the liquid tank. In the drawing the tank is shown on the same floor as the condenser, but just as often it is located in the engine room, and in this case it is usually a vertical tank. The liquid in this tank is under the same pressure as the condenser (135 to 200 lb., depending on the temperature of the cooling water). When the regulating valve is opened the high-pressure liquid flows into the expansion coils in the amount required to maintain the desired temperature. This is, of course, controlled by the number of turns the valve is opened. If the temperature in the coils is below 32 deg. F., and it

usually is, some of the moisture in the air will be condensed and accumulate in the form of white frost on the piping. This interferes to some extent with the absorption of heat from the room, but enough gets through the coating of frost and the walls of the piping to evaporate the ammonia just as steam is made from the water in a boiler when heat above the boiling point is applied. Each pound of the liquid ammonia at the above pressure requires 569 heat units to change it into a vapor. The temperature of the liquid ammonia, however, as it comes from the liquid tank, must be reduced to a temperature corresponding to the lower pressure in the refrigerator, which is usually about 16 lb. gage. This heat then evaporates part of the ammonia, and less than 500 heat units need be absorbed from the room, and whatever this figure, it represents the actual amount of refrigeration available per pound of the liquid fed to the expansion coils.

From the expansion coils the vapor passes through a scale separator, which removes any scale or foreign matter which might injure the compressor as the vapor is now in the suction line. When in the cylinder, it is compressed and is forced through the hot gas line to a pressure tank, if one is employed. In its passage from the head of the tank to the interior it is given a spiral motion to cast out any oil that may have been carried over from the compressor. In some cases this tank is omitted and simply an oil separator installed in the line to the condenser. The vapor then passes through a check valve and enters a header connected to the bottom pipes of the several stands of the condenser. It may be noticed that the hot vapor line rises higher than the condenser, so that none of the liquid it contains can return to the compressor when it is shut down. The condenser is of the atmospheric type with water trickling down from above over the coils of pipe. Before the vapor reaches the top pipe of the condenser practically all of it has been reduced to a liquid, and as fast as this liquid is formed it is drained through small pipes connected from different levels to a liquid header, which discharges to the liquid tank. In case any of the vapor is carried along with the liquid it may escape to the top of the condenser through the equalizer line. It will be noticed that the liquid tank is provided with a drain and close to the entry into the expansion coils a charging valve is provided. Through this valve the system is supplied with liquid ammonia from the shipping drums.

We are now back to the starting point and there is no need for further description, the operation just described is repeated over and over again. The type of apparatus employed may be different, but the general working will be the same and the foregoing outline of the cycle of operation will apply to all types of ammonia-compression plants.

Temperature of Storage Rooms

The following question and answer may be of general interest as the same trouble has, no doubt, been encountered in other plants:

Some angle-type thermometers had been purchased and placed in cold-storage rooms so that the temperature inside of each room could be seen on the thermometer from the outside. The thermometers were placed in the walls first as shown in Fig. 1, and then as shown in Fig. 2, but in each case the reading was 5 deg. higher than a reading taken inside the room. The thermometers were tested and found to be accurate. The walls were 6 in. thick and were lined with cotton-seed husks.

It is rather difficult to place an angle thermometer in the walls of a cold-storage room so that it will register the average temperature of the room. In most cases the temperature near the walls is either higher or lower than the temperature in the center of the room. It is lower when some refrigerating piping is located on the wall on which the thermometer is placed and it is generally higher if there is no piping on the wall. In the former case there is a current of cold air flowing down from the coils over the thermometer bulb and in the latter case warm air rises along the wall to the cooling coils wherever they may be placed.

It is desirable to locate a point on the wall where the temperature taken by an ordinary cold-storage thermometer corresponds to the temperature reading at the center of the room. If no such location can be found it will be absolutely impossible to locate the angle thermometer for a correct reading. In such a case, it is possible, of course,

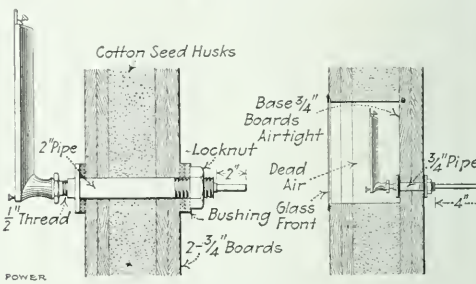


FIG. 1.

FIG. 2.

to find out how much higher or lower the angle thermometer reads than a thermometer placed in the center of the room, and correct the reading accordingly.

On account of the difference in the air currents, it will be found that the temperature in various parts of any cold-storage room will vary considerably, depending not only on the quality of the insulation, but also on the distribution of the cooling pipes and the location of the various walls of the room with reference to the outer air.

Referring to the sketches it would not be advisable to pass the pipe thimble all of the way through the insulation, or even part of the way for the reason that this thimble will transmit heat from the outer air to the thermometer bulb, and consequently influence the reading.

It would be better to install the thermometer so that the only metal attachment is at the outer side of the cold-storage room, while the hole through which the thermometer passes should be filled with insulating material so that there will be no possibility of heat being transmitted to the thermometer bulb from the outside.

As an example of the way in which steam engineering is sometimes done, attention is called to a "call for bids" recently issued by a Western city, which specifies:

One 50-hp. Horizontal Steam Flue Boiler with dome, 150 lb. working pressure, size 48 in. by 14 ft., full front, grates and grate bars, pop safety valve 2½ in., also one 2½-in. extra heavy blowoff valve with wheel.

EDITORIALS

Mixed-Pressure Steam Turbines

In engineering, as in other phases of industrial progress, what is here today is gone tomorrow, and the things of tomorrow are not known. Crude, indeed, would appear the old pumping engines of Newcomen's and Watt's time. The old haystack boilers would also equal them as relics of the olden steam-engineering days. The old slide-valve engine, with its round-rimmed flywheel, and in some instances wooden eccentric rod, would look sadly out of place today; and yet they were all models in their time. Progress has left these old times far behind.

Times have changed; engineers are looking for prime units which will produce the greatest output with the least steam consumption. Because of this constant straining after greater economy, the Corliss engine, various types of four-valve engines and single-valve automatic engines have been designed, and have filled their place in the power plant. In many of the larger power stations, the high-pressure steam turbine, using superheated steam, has supplanted the reciprocating engine, and in other instances the exhaust-steam turbine has been installed to operate in conjunction with the reciprocating engine. Each type of prime mover has represented an advancement in steam engineering, and has probably met all expectations as regards efficiency and economy in operation.

These units all have a place in the power plant, but the turbine is not as efficient as the reciprocating engine when running noncondensing or on a low vacuum. The low-pressure turbine is useless unless the reciprocating unit, to which it is piped, is in operation, because the steam necessary to operate it must come from the engine.

There are times when the load to be carried is not sufficient to give the reciprocating engine an economical steam consumption. To operate the engine under such conditions is a waste of fuel. The exhaust-steam turbine is useless, because it would be folly to operate it in conjunction with the already underloaded engine.

This underload condition has confronted the engineer and power user for years. As a means of obtaining economical operation a small steam unit has generally been installed, so that when the load for the large unit becomes uneconomical, the small unit is started and carries it. When the load is sufficient to warrant the operation of both large and small reciprocating units, fairly good operating conditions exist, but both units are operating with live steam and generally the exhaust steam from both units is discharged to the atmosphere; a loss that can be eliminated in many installations.

It is in such instances that the mixed-pressure steam turbine comes into the field and fills a place in the economic operation of the plant that was not dreamed of a few years ago. With this type of turbine the reciprocating unit furnishes the low-pressure steam during the period it is in operation and the exhaust steam, as in the case of the exhaust-steam turbine, is utilized in doing useful work. But unlike the ordinary exhaust-steam turbine, when the main reciprocating engine is shut down, the mixed-steam turbine is still a useful unit, because it is capable of operating with live steam from the boilers.

If there are pumps exhausting to the atmosphere, this steam can be piped to the turbine and made to produce energy instead of being wasted. Running at night, when the load is light and the main unit is shut down, is a condition suitable for this class of turbine. In the morning when the large reciprocating engine is started up, the turbine can be changed back to exhaust steam without a moment's delay, and the generator of both units operated in parallel.

The mixed-steam turbine can be run with low-pressure steam entirely, with a partial supply of exhaust and high-pressure steam, and with high-pressure steam alone. This makes a combination capable of meeting the requirements of most steam plants in which this type of turbine can be utilized.

Of course, the condenser outfit must be added to the installation cost of the turbine, because it is necessary for the operation of the turbine. But for all that, the arrangement is eminently capable of increasing the economy of operation of the reciprocating plant, where conditions warrant its installation.

The Oil-Fuel Problem

The statement that crude oil will no longer be offered for sale by a certain important oil company, a company that has considerable influence on the oil market, has been made authentically. The obvious reason is the greater profit from the sale of the byproducts of petroleum. Naturally, this policy, if carried out, will seriously affect the cost of power production in a great many plants and the possibility of such a situation deserves the careful thought and study of all classes of manufacturers and power-house operators.

The oil deposits of the country are far from being exhausted—many of the large oil fields still remaining practically untouched—and the cost of sinking wells, transporting the oil, etc., are not much greater today than ten years ago. During this time, however, the demand for gasoline has increased tremendously, it is true, and, of recent years, the wide introduction of fuel-oil engines has created an increased market for crude and the heavier oils.

The increased demand for gasoline would naturally explain the elevated price of that commodity, a natural result, if the demand has increased more than twice as rapidly as the supply—more than twice as rapidly, for the price of commercial gasoline has nearly doubled during the past ten years, while at the same time its quality has steadily declined. That is, gasoline as procurable today is no longer as pure as it was formerly, but contains a quantity of benzolene and probably a considerable proportion of the more stable benzines or

naphthas. In other words, the "gasoline" obtained from a given quantity of crude oil is five to eight times as much as formerly. The market price having nearly doubled, the gasoline value of petroleum would appear to be ten to fifteen times as great as in the days when commercial gasoline was of a higher grade, for the cost of distillation remains comparatively the same—any increase being considerably under one hundred per cent. In addition, there is another relatively recent source of income from the distillation of crude oil; liquid distillate, the fuel secured by passing certain of the lighter distillate gases—gases driven off before the more stable gasoline in refining crude oil—through water. The fuel thus obtained has a power-generating value, in stationary engines at least, that is very nearly as great as that of the present commercial gasoline and which sells for but a slightly lower figure.

Crude oil has recently been selling at a price that is fully three times as great as that at which the same commodity was sold within recent years and, though this may be explained in a measure by the increased demand for gasoline, the same argument or excuse cannot be advanced for the present high price of fuel oil. Fuel oil is not necessarily crude oil. In fact, an excellent fuel oil, and the oil generally sold as "fuel oil," is the residue after the gasoline has been distilled from the crude. With the gasoline value of crude oil probably ten to fifteen times as great as formerly and the added income from liquid distillate, it would seem that the price of fuel oil should not have increased to such an extent, even if crude does sell for three times the amount it formerly commanded. In the past, fuel oil sold for less than the price demanded for crude oil. Today the price for fuel oil is not much less than that for crude oil, else there would not be the demand for crude oil for power purposes. The really phenomenal growth in oil-engine installations that would be necessary to create such a demand for fuel oil as to justify the present price of that commodity is not apparent, neither is the increased market for the heavier byproducts of petroleum much greater than the increased supply of crude oil. The oil industry would appear, therefore, to have been rather an unprofitable one in the past in order to justify the present market prices of crude oil, gasoline and fuel oil.

What the Tenants Pay

Engineers have wondered why owners of office buildings and large apartment houses purchase central-station current instead of putting in an isolated plant to serve the tenants. Occupants of such buildings are charged enough for electrical energy to make a neat profit for the central station. Why should not the same class of customer be attractive to the isolated-plant owner?

The average rate paid by tenants of apartment houses and office buildings, unless lighting is included in the rent, is ten cents per kilowatt-hour, but the central station does not get this rate, although it is charged in the bills rendered. As a matter of fact, the owner of the building or landlord pays the central station about four and a half cents for the same current and pockets the difference as his profit on an investment of nothing.

This practice, which obtains in New York and undoubtedly in many other cities, makes it clear why more isolated plants are not found in such buildings. There is no incentive to put in machinery to generate private electrical energy, when about fifty per cent. of each tenant's lighting bill goes into the landlord's pocket. This profit is not interest on an investment, it does not represent income from a legitimate business, but it does represent a form of graft that should be stopped.

If the central station can and does sell current to the landlord for about four and half cents per kilowatt-hour it is a clear case of robbery to charge the tenant ten cents for the very same current. This situation in New York, we understand, is being investigated by the Public Service Commission. It is to be hoped that the commission will put a stop to the holdup.

Time for Repairs

Now that the heating season is at an end, the time is appropriate to begin repairs. Another month will bring with it hotter weather and this will lessen the ambition to get at the jobs in nooks and corners that require attention. The leaks and defects that were the source of so much trouble the past winter, might require but little work to right, and if done now, while the memory is fresh, it will mean fewer burns and better service when it is again time for the system to be used.

If there are traps be sure that they are clean and in good working order. If trouble has been experienced in heating the distant points, perhaps a larger or more direct line would give better satisfaction. If it would, do not wait until the last few weeks of summer before making the changes. With a vacuum system it is important to examine the valves and packing of the pump. Do not leave it in a condition that might cause trouble at a critical moment. Remember that there is a steam end and valve gear that require attention. In short, see that the system is in condition to give first-class service when the season opens.

How would you like to be—no, not the iceman—the chief boiler inspector of Allegheny County, Penn.? He gets three dollars for every boiler inspected and, by law, every boiler in the county must be inspected annually. From Aug. 6, 1912, to Feb. 5, 1913, his staff inspected 3542 boilers—a rate of over seven thousand boilers a year. Then the income of the office cannot be under twenty-one thousand dollars, although it is claimed never to have reached twenty-five thousand dollars. Out of this sum the chief inspector pays office rent and the salaries of five inspectors, a bookkeeper and a clerk. Now if you were the chief inspector, do you think you could worry along on what he has left?

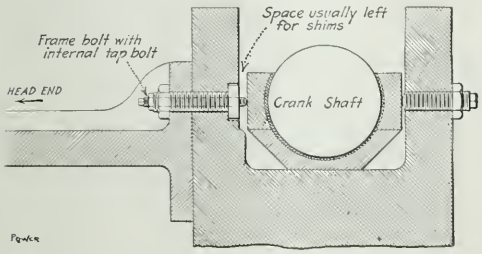
Governor Sulzer, of New York State, has signed the Jackson bill which seeks to give greater protection to the employees of factories. If it is of concern to the state to protect operatives in the industries by providing safety devices on machinery and taking precautions against death and sickness from occupational diseases, it should be its concern to guard the public as well from injury due to boiler explosions. As the legislature has just passed the Jackson bill it indicates that its present membership is kindly disposed toward humanitarian measures which gives reason to hope that the Willmott bill on boiler inspection may receive favorable consideration.

READERS WITH SOMETHING TO SAY

Recommends New Feature in Pillow-Block Design

In nearly all horizontal engines the crank pillar is bolted on to the engine frame. The quarter boxes are adjusted at the head end with liners and, on the opposite side, tap bolts are used with jam nuts on them.

It would be a good idea to so design the position of the two top frame bolts that a center line through them would also come in the center of the head-end quarter box, as shown. The bolts could be made larger in diameter and a hole drilled through their center and tapped out. Into this hole a tap bolt could be screwed and by this means the bearing could be adjusted to the journal, as indicated by the illustration.



PILLOW-BLOCK BRASSES ADJUSTABLE FROM HEAD AND CRANK ENDS

At present, with these engines, if there is not time to take the bearing apart, the knock or pound is overcome by screwing up on the two crank-end tap bolts; this throws the main shaft out of line as the quarter boxes usually wear equally. By means of the frame bolts being fitted with internal tap bolts, the wear could be taken up equally.

J. A. CAMPBELL.

Providence, R. I.

Two Engine Wrecks

The engine in the plant of the American Laundry, Flanders St., this city (Portland, Ore.), was wrecked recently. The engine was a medium-speed automatic-balanced slide-valve type of about 60 hp., belted to the line shaft and had been in use about four years.

The disk gave way as the piston was on the forward stroke. The momentum of the flywheel together with that of the line shaft carried the crankshaft over the center, opening the valve for the return stroke which drove the piston against the head, forcing it off the rod, bending the rod and breaking the main frame and cracking the cylinder. The piston, cylinder head and part of the cylinder were carried about four feet, striking an 8x8-in. post that supported a large heater. The post was moved several inches.

Steam was at once shut off at the boilers and no one was injured. No blame was given the engineer in charge as an examination showed that the crank disk had been cracked, presumably by too tight a fit of the crankpin when the engine was built. A new engine of the same class was at once secured, a force of mechanics put to work and the plant was ready to run the next morning.

A 9x14-in. high-speed automatic center-crank engine belted to two dynamos in the mill of the Standard Box & Lumber Co., Portland, Ore., was wrecked a short time ago. The piston rings were in three sections set out by springs. Each section was made up of three pieces riveted together. The rivets in one section sheared, allowing a part of the ring to drop. It caught on the counter bore, and at the commencement of the stroke the cylinder was split. As the cylinder and frame were one piece a complete new frame had to be ordered from the East. No one was hurt and the property loss was confined to the engine.

C. F. KING.

Portland, Ore.

Unusual Experience with Pump

Instructions were received to examine a duplex pump, the owners having reported that the pressure gage greatly fluctuated and that the water column in the discharge pipe was very unsteady. On arrival at the pump house, I found that the pump was driven by a horizontal Corliss engine and that it was running when I arrived.

I found things just as reported—the pressure gage very unsteady, owing to surging of the water in the discharge pipe. This surging was very noticeable when one stood on the ground which covered the discharge pipe outside of the building.

I listened, with my ear close to all four corners of the pump, thinking that some of the valves were missing or leaking badly, but I could not detect any trouble and to look and listen in the pump house everything seemed to be running satisfactorily; so it seemed to me that there might be some high spots in the discharge pipe between the pump and the reservoir, but the engineer assured me that there was a small relief cock at all the known high places and that these cocks were leaking water so that I need not look for air pockets in the discharge pipe.

The pump had no suction lift, as the water flowed from a tank to the pump. The water level in the tank would bring the water about one foot above the top of the pump delivery-valve chamber. There was no check valve between the pump and the discharge pipe; there was a gate valve on the discharge pipe close to the pump.

I noticed that one corner of the pump looked lighter in color than the other three corners, so I at once put my hand on this corner and found the casting perfectly dry while the other three were quite moist to the hand. One

corner of the pump was air-bound. Hence, the reason it was dry. The plungers were outside packed and each plunger chamber had a handhole on the side. With the pump still running, I slacked off the nuts on the handhole plate about $\frac{1}{8}$ in. and wedged it off until the water came out. This released the air and the trouble was over.

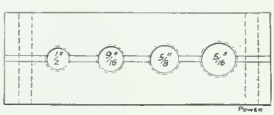
To prevent any such trouble in the future, I drilled a hole for a $\frac{1}{4}$-in. pipe under the discharge valves of each corner and put in a $\frac{1}{4}$-in. globe and check valve. Water or air could not blow out of the check valve; but if the water in the tank was low, the check would close on the suction stroke. When certain that the air was out, the globe valves were closed.

JOHN ASHFIELD.

Oakland, Calif.

Holder for Threading Stud-Bolts

The engineer is often called to make stud-bolts, and if the proper tools are not at hand it is a difficult thing to do so. It will be quite easily accomplished if one will take two pieces of machine steel, 1 in. square and about 6 in. long and place them side by side with a $\frac{1}{8}$-in. strip between them and clamp them tightly together. Now drill and tap four or more holes, say, $\frac{3}{4}$, $\frac{5}{8}$, $\frac{9}{16}$ and $\frac{1}{2}$ in., as indicated in the sketch, and after doing this remove the clamp and discard the thin strip. Now drill a hole at each end at right angles to the tapped ones, say, $\frac{5}{16}$ in., for a bolt to hold the two pieces together. Now insert a



HOLDER FOR THREADING STUDS

stud in the size hole corresponding to the thread in the two pieces and clamp the two pieces together with the bolts at each end. The holder being held firmly in a vise will enable one to close-thread the stud.

The same thing can be accomplished by sawing a nut (of the size stud used) in two and placing the two halves over the threaded end of the stud and clamping them in the jaws of the vise.

J. L. HARPOLE.

Hopkinsville, Ky.

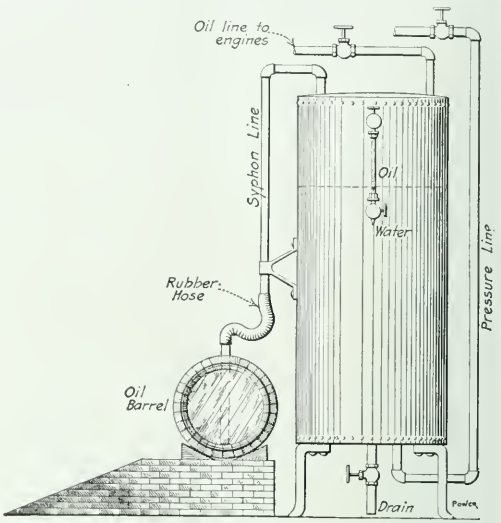
Siphon Oil-Barrel Emptier

After trying a number of methods for emptying barrels of oil directly into the oil reservoir, we have at last got one which seems to excel all others for simplicity and ease of operation. The sketch gives an idea of this emptier and filler.

The large reservoir is made of heavy sheet iron and is capable of holding a couple of barrels or more. It stands full of water, or oil and water, as the case may be. The pipe line entering it at the top and bottom, respectively, are for the delivery of oil to the engines, pumps, etc., and, as we use steam pressure, for the reception of the condensate from the steam line. Another line, with a valve, connects the top of the tank with the oil barrel.

The principle used in conveying the oil to the tank is that of the siphon. The barrel is rolled to a point of elevation above the discharge of the drain in the bottom of the tank.

After closing the valves on the lines where pressure is maintained, and with the oil tank nearly full of water, the drain-line valve is opened to relieve the pressure in the tank. The valve in the siphon line is then opened and the weight of the atmosphere forces the oil from the



SIPHON-BARREL EMPTIER READY FOR SERVICE

barrel into the tank where a partial vacuum is formed by the water gravitating from the tank. The drain must be promptly closed when the barrel is empty or the contents of the tank will be lost.

EDWARD T. BINNS.

Philadelphia, Penn.

Piston Rod Breaks Third Time

On Mar. 22 occurred the third accident to our small high-speed engine within 13 months.

The piston rod broke off in the crosshead and knocked out the cylinder head, which hit an iron door that, when swung back, is directly in front of the engine cylinder. There was a large hole knocked in the brick wall.

The cylinder-head bolts were all broken off and the stuffing-box nut and the oil plate between the guides and cylinder were broken.

The rod through the stuffing-box was $1\frac{7}{8}$ in. in diameter and was tapered down to $1\frac{1}{16}$ at the crosshead before the threads were cut, and was $1\frac{35}{64}$ in. in diameter at the bottom of the thread. According to my calculations these dimensions do not figure out correctly for 100 lb. pressure, being too small. We had the crosshead bored out and the rod made the same diameter the entire length. This engine has been in service for about eight years, and so far as I know has never given any trouble.

Fortunately, no one has been hurt in these accidents, but we have taken the pains to fence in the engine so one cannot walk in front of the cylinder.

G. W. HUBBARD.

Cherokee, Iowa.

Whistling Pump

A deep-well pump, the 4-in. discharge pipe of which was hung about 3 ft. below the engine-room floor was part of our equipment. The pump discharged into a cistern about 20 ft. from the pump. A ½-in. pipe was tapped into the 4-in. pipe and was once used for a drain from the steam cylinder. When its use was discontinued the ½-in. pipe was left projecting about 1 in. above the floor line. The pump operated in this manner for several years without making any unusual noises, when rather suddenly there occurred with every up stroke of the pump air would whistle up through this pipe caused by the water that was discharged into the 4-in. pipe.

GAY A. ROBERTSON.

Louisville, Ky.

Interesting Indicator Diagrams

It would interest me and perhaps others to have readers comment on the accompanying indicator diagrams, Figs. 1 to 9, taken from compound condensing marine engines and pumps. Both the port and starboard main engines and pumping engines have piston valves for the high-pressure sides. The main engines have the Allen slide valve on the low-pressure side, and the pumping engines have the common D-slide valve on the low-pressure side.

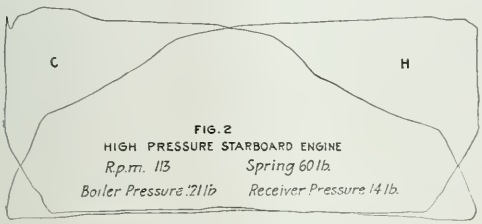


FIG. 2
HIGH PRESSURE STARBOARD ENGINE
R.p.m. 113 Spring 60 lb.
Boiler Pressure 121 lb Receiver Pressure 14 lb.

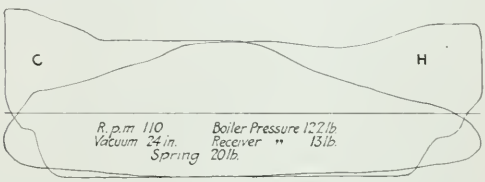


FIG. 3 - LOW PRESSURE STARBOARD ENGINE

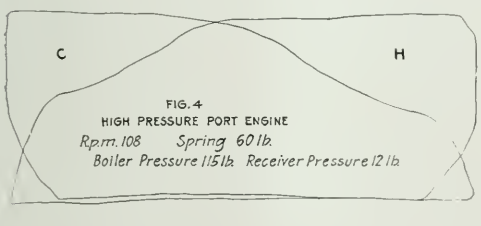


FIG. 4
HIGH PRESSURE PORT ENGINE
R.p.m. 108 Spring 60 lb.
Boiler Pressure 115 lb. Receiver Pressure 12 lb.

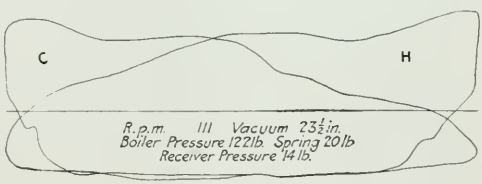


FIG. 5 - LOW PRESSURE PORT ENGINE

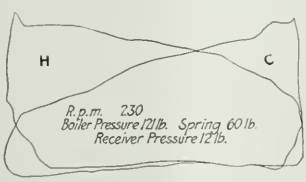


FIG 6
HIGH PRESSURE PORT PUMP

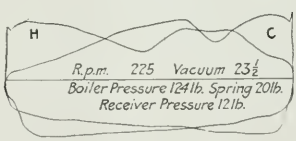


FIG. 7 - LOW PRESSURE PORT PUMP

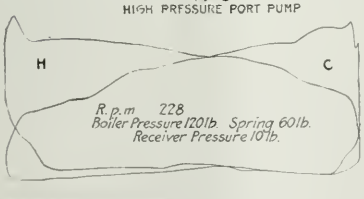


FIG. 8 - HIGH PRESSURE STARBOARD PUMP

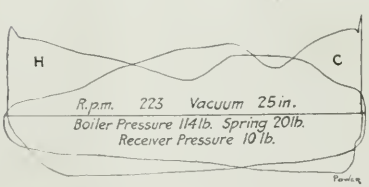


FIG. 9 - LOW PRESSURE STARBOARD PUMP

DIAGRAMS FROM COMPOUND CONDENSING ENGINES

a very perceptible whistling noise, as though the rod or cylinder were dry. Oil and graphite liberally applied did not stop the noise. The mysterious noise worried the engineer for several days, but while looking for the trouble, he accidentally covered the end of the ½-in. pipe with his foot and the noise stopped at once. Upon investigating, it was found that with each up stroke of the pump

The receivers of the pumping engine are of cast iron running from end to end. This type of receiver is, I believe, the cause of the hump in the steam line of the diagrams from the low-pressure side of the pumps. The main engines are each of 30 and 15 by 12 in.; the pumping engines are each 22 and 12 by 14 in.

Savannah, Ga. OTTO RICHTER.

QUESTIONS BEFORE THE HOUSE

Factor of Evaporation

A. L. Westcott's letter, in the Apr. 1 issue, commenting on A. A. Potter's, "Factor of Evaporation," in the Mar. 11 issue, was read with interest. This is a somewhat confused subject. The equivalent evaporation is determined from the actual evaporation and is equal to the actual evaporation times the ratio of heat content of one pound of steam above feed-water temperature under actual conditions to the heat required to vaporize one pound of water from and at 212 deg. F.

This computation may be made in either one or two steps. The items quoted by Mr. Westcott from the A. S. M. E. code are correct, but are somewhat ambiguous in their statement. Item 59 reads: "Water actually evaporated, corrected for quality of steam." If Mr. Westcott will look up App. xviii and xix to the code, he will find that this item is not, water fed to the boiler times the quality of steam, where the quality is one minus the decimal representing moisture, but the water fed to the boiler times a factor of correction determined from the quality, as shown below. This item 59 is the weight of water which would have been evaporated had the steam been dry and saturated, with the same heat input under existing conditions of feed temperature and steam pressure. The equivalent evaporation is then found by multiplying item 59 by the factor of evaporation for dry steam. That is, item 61 = item 59 × item 60 = items 57 × factor of correction and item 60.

But this item by definition is also equal to item 57 times the actual factor of evaporation where the actual factor of evaporation is the ratio above mentioned. We can write from the above,

actual factor of evap. = *factor of correction* × *item 60*

or factor of correction =

$$\frac{\textit{Actual factor of evaporation}}{\textit{factor of evaporation for dry steam}}$$

But we may write

$$\text{Actual factor of evaporation} = \frac{xr + q - q^o}{970.4}$$

$$\text{Factor of evaporation, dry steam} = \frac{r + q - q^o}{970.4}$$

Where

x is the quality of steam (minus decimal representing moisture content);

r is latent heat of vaporization at actual pressure;

q is heat of liquid at temperature corresponding to steam pressure;

q^o is the heat of the liquid at feed temperature.

We may then write

$$\textit{Factor of correction} = \frac{xr + q - q^o}{r + q - q^o} =$$

$$\frac{xr + xq - xq^o + (1 - x)(q - q^o)}{r + q - q^o} = x + \frac{(1 - x)(q - q^o)}{r + q - q^o}$$

$$= \textit{quality} + \frac{\textit{heat in moisture}}{(\textit{total heat per pound dry steam above feed temperature})}$$

Taking the example, as cited by Mr. Westcott, and computing the evaporation by the two different methods we have

Water fed to boiler per hour..	= 5000 lb.
Absolute steam pressure....	= 150 lb. per sq.in.
Per cent. moisture in steam.	= 3
Feed-water temperature.....	= 130 deg. F.

1. Actual factor of evaporation =

$$\frac{0.97 \times 863.2 + 330.2 - 97.89}{970.4} = 1.102$$

Equivalent evaporation =

$$1.102 \times 5000 = 5510 \textit{ lb. per hr.}$$

2. Factor of correction for quality =

$$0.97 + \frac{0.03\ (330.2 - 97.89)}{863.2 + 330.2 - 97.89} = 0.9764$$

The water actually evaporated corrected for quality would be

$$5000 \times 0.9764 = 4882 \textit{ lb.}$$

Factor of evaporation, dry steam =

$$\frac{863.2 - 330.2 - 97.89}{970.4} = 1.129$$

and equivalent evaporation =

$$4882 \times 1.129 = 5510 \textit{ lb. per hr.}$$

which is the same as by the previous method.

The first method is much to be preferred, for not only is it simpler, but the second method is ambiguous, as the quality is frequently used in computations instead of the factor of correction.

It is true that such a method might be advocated on the ground that the heat in the moisture contained in the steam should not be credited to the boiler as it is of no value to the engine. There are numerous arguments pro and con on this question, but the general consensus of opinion seems to be that the boiler should be considered only as a heat absorber and as such should receive all credit for heat contained in the steam, including the moisture content.

L. C. ROBERTS.

Milwaukee, Wis.

Wavy Suction Lines on Indicator Diagrams

The wavy suction lines shown on the indicator diagrams submitted by J. E. Reynolds in POWER of Apr. 8, may be due to the absence of an air chamber on the suction line, or, if one is provided, it may be located too far from the pump to be effective. Assuming that an air chamber of correct proportions is installed close to the pump, the absence of air in it would tend to produce the conditions indicated, in that no shock-absorbing medium, necessary to absorb and steady the fluctuations, caused by

the high velocity and reversal of flow of the water at this point of the stroke, is present.

I would suggest that Mr. Reynolds equip this air chamber with a water glass to ascertain whether or not any air remains in the chamber, and if not, that he open the pet-cock at the bottom of the glass until air fills the chamber about two-thirds full, and then take some indicator diagrams.

If the condition presented is accompanied by a slam of the water valves and a jump of the plunger at the beginning of the suction stroke and the same cannot be eliminated by use of the across exhaust or cushion valves, preferably the latter, I would recommend that he connect a ½-in. pipe from the top of the suction-air chamber to the vacuum pump or condenser to remove the air and hold the water up above the center of the plungers. After the air has been removed it can be kept out and the water held up with a valve in this ½-in. line only slightly opened.

W. Oliver.

Racine, Wis.

In Massachusetts

In the Mar. 11 issue I read with interest the editorial on the Massachusetts license law. Although correct, inso far as the local papers have stated it, there are some things which do not appear according to law.

Any man in this state holding a second-class license may have charge of and operate an engine or engines, no one of which exceeds 150 hp., or may operate a first-class plant. If a plant contains an engine over 150 hp., it is a first-class plant. Not many years ago a person who could qualify could receive a special license to have charge of any plant, but the law has been changed so that now no special license will be granted to have charge of a plant other than a second-class one.

As long as a plant remains the same, a man who received a special license to have charge of a plant under the old law can continue to do so at the present time, but if new engines are installed his license becomes useless.

Here is where the inspector whose sails were to be trimmed found the greatest number of violations. In some cases plants had been entirely rebuilt and larger engines or turbines installed, and still they were in charge of special license men, whose licenses were granted for the old plant.

The men who did this were violating the law just as much as though they held no license whatever. The representative from this part of the state who introduced the special license bill hoped to enable those plants to continue in charge of a special man. The power-plant owners themselves argued that removing these men threw out of employment men who had worked for them for years, and imposed a great hardship on men who had no other trade.

The bill failed to pass. Also, according to latest reports, the local inspector's sails are still flying and whenever he prosecutes he seems to have no trouble in winning his case.

Cheshire, Mass. A. W. Griswold.

[According to the ruling of the Board of Boiler Rules, a second-class license entitles the holder "to operate a first-class plant under the engineer in direct charge of the plant.—Editor.]

Value of Engine Inspection

It was necessary to renew the piston rod on a Corliss engine. A new rod was made, but when about to place the new rod in the bull ring it was discovered that there were three cracks in the body of the bull ring, which, of course, made it necessary to also make a new ring. Had it not been necessary to take the piston rod out of the bull ring the bad condition of the latter would not have been noticed until, perhaps, a serious accident happened.

This piston was examined about every six months, but the cracks in the bull ring were not noticed and I believe they would not have been found but for the fact that the piston rod and bull ring had to be heated to get the old rod out, which, of course, opened up the cracks so they could be seen.

H. A. Jahnke.

Milwaukee, Wis.

Piping Mine-Pump Air Exhaust

With reference to Mr. Houston's letter in the Apr. 22 issue, it is not stated clearly how he forces the exhaust from the air-driven pump into the discharge from the water end. He states that the pump operates against a head of 400 ft., or a pressure of 173 lb. per sq.in. It is difficult to understand how the exhaust from a pump taking air at an initial pressure of 90 lb. per sq.in. can be made to pass through a check valve with 173 lb. water pressure on the other side of it. An explanation of the above would be interesting.

Incidentally, Mr. Houston could have prevented the freezing of the exhaust by admitting a small stream of water near the end of the exhaust line. This is a very simple and effective method and causes no loss of power due to back pressure.

George H. Bridges.

Holyoke, Mass.

A Flood Experience

In reference to your editorial "The Afflicted Middle West," in the Apr. 8 issue, I want to say that the men in charge of the municipal plant here were certainly "up against it." The plant is near the river and was soon surrounded by water when the river began to rise. But the men stayed on the job, working with boots on until forced to abandon the plant, from which they were taken in boats. The traction company's power plant, being on higher ground, escaped the flood, and, although there is keen competition between the two companies, the traction company offered to supply current to all downtown users through the city mains. The offer was made to the city officials, and gratefully accepted.

They worked day and night, with the assistance of the Ft. Wayne General Electric works, getting things baked out. Ft. Wayne was the first city in the flood zone to have light. The water-works pumping station was also flooded, and the supply cut off three days. Then two locomotives were placed as near the pumping station as possible and a steam line was run to the pumps, which were still under water, and they began to pump water for domestic purposes. It takes a real engineer to be an engineer at a time like this.

Ft. Wayne, Ind. J. W. Fries.

Large High-Vacuum Condenser Test

Referring to the article on page 278 of the Feb. 25 issue, on the test recorded by J. J. Brown, covering a 25,000-sq.ft. turbine-base surface condenser; 36-in. double-suction volute pump, driven by a Corliss engine; 14x36x24-in. dry-vacuum pump and two double-suction hotwell pumps; the writer has figured, according to the geometric mean, the B.t.u. heat transference of the five guarantees as specified on page 280, using the formula given on page 281, in accordance with which the guarantees, all based on circulating water at 70 deg., 34,000 gal. per min., are as followed:

28 3-in. vacuum, 210,000 lb. of steam per hour 427 B.t.u.
28 5-in. vacuum, 185,000 lb. of steam per hour 449 B.t.u.
28 6-in. vacuum, 155,000 lb. of steam per hour 396 B.t.u.
28 7-in. vacuum, 125,000 lb. of steam per hour 349 B.t.u.
28 9-in. vacuum, 70,000 lb. of steam per hour 266 B.t.u.

These guarantees can be met by a new apparatus in good condition and clean tubes.

The circulating-pump conditions as given are apparently correct, figuring up to a head of 14 ft. when 36,000 gal. per min. are delivered through the condenser, which checks.

In Table 2 is a test in July, 1910, where the heat transference is recorded as varying from 403 to 550 B.t.u.; the latter figure is given in only one instance and under the following conditions: Vacuum, 28.286 in.; the temperature corresponding to vacuum, 96.15 deg.; hotwell temperature, 90.3 deg.; circulating water, 73.4 deg.; inlet, 86.9 deg.; outlet, steam condensed, 210,000 lb. per hour.

No mention is made of where the vacuum reading was taken, nor whether it was taken simply through a hole drilled in the base, or through a perforated pipe, so that the velocity of the steam would not affect the reading. It should have been taken in the latter way, and at several points; also, the steam temperature should be an actual reading and not recorded as the temperature of steam corresponding to the vacuum, as in this test, without any statement as to where the vacuum reading was taken. It will be noted in the article that this condenser contains rain-plates.

It is fair to assume that there was a considerable loss in pressure between the space beneath the turbine buckets and the dry-air suction openings, and if the reading given was taken at the air-pump suction, and there should be 1 in. loss through the condenser, the figures will change as follows: Vacuum, 27.286 in.; temperature corresponding to vacuum, 111.6 deg.; steam per hour, 210,000 lb.; hotwell temperature, 90.3 deg. circulating water, the same as given by Mr. Brown. These conditions, instead of giving 550 B.t.u. transference, give only 266 B.t.u., a very poor instead of a very good efficiency. It is necessary to give the readings both at the air-pump suction and beneath the turbine buckets and the test record is incomplete and misleading without such particulars.

On page 280, Table 1, is a test of the dry-vacuum pump, the mechanical efficiency being figured from the mean effective pressures in the steam and air cylinders and their relative volumes. This efficiency averages about 85 per cent., but no statement is made as to the vacuum maintained, which is very important, since a dry-vacuum pump obtains its least efficiency at perfect vacuum, and its highest mechanical efficiency at the greatest load, which is at about 19 in. vacuum. I judge from the average mean effective pressure recorded from the air cylinder, about 15.4 lb. per sq.in., that the machine was operating with between 27 and 27½ in. vacuum when these readings were taken, under which conditions it would show a higher efficiency than when operating under the guaranteed conditions of between 28.3 and 28.9 in.

It would be interesting to know whether Mr. Brown would guarantee these efficiencies when operating a high vacuum covered by the five conditions upon the apparatus. Under test conditions, somewhat better results are likely to be obtained than under running conditions, for which the guarantees should be suitable.

Carl George de Laval.

Orange, N. J.

Firemen—and Firemen

The foreword, "Firemen—and Firemen," in the Apr. 29 issue, gives the impression that the Mallet locomotive fireman's work is unusually hard, the hours long and the compensation small.

The firemen represented at the hearing mentioned in the note at the top of the page are mainly employed by Eastern railroads, and the locomotive firemen in New England have much the best of the comparison. To begin with, there are no Mallet locomotives used in this section. It is a mighty poor fireman who cannot earn $75 per month on any run where he can put in at least 60 hr. per week. On some express runs his actual time is 40 hr. per week, for which he receives over $100 in the month.

Consider the duties of a locomotive fireman, such as cleaning, etc. Once he had to polish the brass and clean the locomotive. Today he cleans nothing below the running board, and what he does clean is usually very poorly done. Frequently the runs are short, with many stops, so that he has just as much of a snap as many of the stationary firemen.

As to the fierce heat, almost any stationary boiler will scorch one's clothes if it is run hard enough. Where a stationary man has considerable space to cover in firing, and the coal is not always handy, he frequently has to go outdoors and wheel it in as it is needed. On a locomotive the coal is always at hand, there is never more than two doors to fire into, and the fireman does not lift or throw the coal in large shovelfuls.

I do not believe the foreword represents the facts. New England firemen after 60 hr. work on the lightest runs get more than the above mentioned wages. According to one prominent railroad, the men are paid by the mile, and as the Mallets will cover many miles, the firemen should make good wages.

After reading such a statement many might believe that locomotive engineers and firemen are down-trodden and underpaid, but, as a whole, they are far stronger and better organized than any of the stationary engineers or firemen and are much better paid.

Neither must they possess the general knowledge required of the stationary engineer. While it does not pay to have a grouch or sit and think how hard our lot is, I do think the locomotive fireman's job is no harder than that of the stationary fireman.

G. H. Kimball.

East Dedham, Mass.

INQUIRIES OF GENERAL INTEREST

Operating Turbine without Dry Air Pump—In a modern turbine station, how could the turbine be kept running if the dry air pump should give out?

R. A. C.

Failure of the dry air pump would mean a reduction of the vacuum, which could only be compensated by raising either the pressure or the amount of steam admitted to the turbine either in the initial or secondary stages.

Single-Eccentric Corliss Engine Cutoff—How late in the stroke can a single-eccentric Corliss engine cut off, and why not later?

J. K.

Usually such an engine does not cut off later than one-half stroke, and cannot be made to do so without interfering with the proper action of the exhaust valves.

Sizes of Water-Tube Boilers—What limits the size of water-tube boilers equipped with mechanical stokers? Why not make them 3000 or 5000 hp. instead of 300 to 600 hp.?

R. A. C.

There is no limit to the size except as a matter of convenience and for commercial reasons. Boilers are not made larger because of the necessity of cutting out too much capacity when one boiler is down for cleaning or repairs. Further, larger units could not as closely aggregate any given capacity required and little elasticity for the supplying of variable demands for steam would be possible.

Steam Regenerators—How much water should a steam regenerator contain in relation to the size of the turbine it serves?

W. T. F.

Generally about ten times the quantity of water used per hour by the turbine, i.e., the weight of water in the regenerator should be about ten times the weight of steam consumed per hour by the turbine.

Diamond Patch on Boiler—A diamond patch is to be put on a boiler having a seam efficiency of 75 per cent., and the patch efficiency is to be the same. How should it be applied?

G. H. A.

The patch corners should be rounded. If the sides make an angle of 45 deg. with the boiler axis, single riveting will be as efficient as double-riveting of a horizontal seam. The latter being 75 per cent. with the same size and pitch of rivets for the patch, its efficiency will be the same.

steam turbine determined?

W. T. F.

Steam-Turbine Horsepower—How is the horsepower of a

The theoretical horsepower of a steam turbine is determined from computation of the energy developed by the steam which is used, in falling from the initial to the discharge pressure of the steam. The actual horsepower is determined by measuring the electrical load driven by the turbine, or by an absorption dynamometer.

Necessity of Dry Air Pump—Are dry air pumps necessary with all condensing turbine installations? If not, why not?

R. A. C.

No, they are not with certain apparatus. Tests have been made in which as high as 29 in. of vacuum was obtained and no dry air pump used. With ordinary condensing equipment the dry air pump is preferable but not necessary. Its advantage is that it reduces the size of wet vacuum pump required by relieving the latter of handling vapor and air and thereby increases the degree of vacuum that can be maintained.

Triplex vs. Duplex Power Pumps—What are the advantages of triplex as compared with duplex power-driven pumps?

T. H. M.

The advantages are that the discharge of the triplex pump is steadier and there is less clattering of the check valve on the boiler or tank supplied by the pump. The disadvantages are that there is rather more piston or plunger friction in proportion to the amount of water handled and for pumps of equal capacity, the triplex having smaller pistons or plungers and also smaller water passages, there is greater frictional resistance offered to the water and the percentage of slip is higher.

Water-Turbine Supply—With a fall of water available of 67 in., how many cubic feet of water per minute would be necessary to operate a 20-hp. turbine?

J. A. B.

If by available head is meant the head over and above all losses sustained in bringing the water to the wheel, or by back water in the tailrace the available head can be taken as the actual head. Probably there is some loss at the point where the water is discharged from the wheel by "piling up." To allow for this it would be about right to deduct 7 in., leaving 60 in., or 5 ft., as the actual working head. A good turbine will have an efficiency of about 75 per cent., so that the "horsepower in the water" would have to be

$$\frac{20}{0.75} = 26.66, \text{ or}$$

$$26.66 \times 33{,}000 = 879{,}780 \text{ ft.-lb. per min.}$$

Falling 5 ft., the weight of water required would be

$$\frac{879.780}{5} = 17{,}595.6 \text{ lb., or}$$

$$\frac{17{,}595.6}{62.4} = 281.9, \text{ or, roundly, } 282 \text{ cu.ft. per min.}$$

Pop Valve Sizes—Two boilers are of the same dimensions and same tensile strength, but one carries 150 lb. pressure and the other 100 lb. Which should have the larger pop valve?

J. P.

Regardless of whether or not the boilers are of the same tensile strength the one at lower pressure should have the larger valve to relieve it of the same weight of steam in a given time. This is shown by the familiar formula for the area of safety valve to use under given conditions, i.e.,

$$A = \frac{W70}{P} \times 11,$$

where

A = Area of valve in square inches per square foot of grate;

W = Weight of water evaporated per square foot of grate.

P = Pressure (abs.) at which valve is set.

Other things being equal the valve area must be increased when the pressure is decreased. The boiler being safe up to 150 lb., the same size valve would be large enough, so far as the boiler is concerned, but for the piping and equipment beyond the boiler there may be reason to keep the pressure from exceeding 100 lb.

Contents of Boiler—What will be the water contents in cubic feet of a horizontal tubular boiler 66 in. in diameter, 16 ft. long, having 57 tubes 4½ in. in outside diameter, and the water level 15 in. from the top of the shell?

R. S.

The volume of water in the boiler will be the net cross-sectional area multiplied by the length (16 ft.). The cross-sectional area will be the cross-sectional area of the shell minus the cross-sectional areas of all the tubes minus the cross-sectional area of the steam space (a segment of a circle).

The cross-sectional area of the shell is

$$\frac{66 \times 66 \times 0.7854}{144} = 23.758 \text{ sq.ft.}$$

of the 57 tubes

$$\frac{4.5 \times 4.5 \times 0.7854}{144} \times 57 = 6.294 \text{ sq.ft}$$

of the steam space

$$\frac{0.13395 \times 66 \times 66}{144} = 4.052 \text{ sq.ft.}$$

(for the method see Engineers' Study Course, "Power," Apr. 1, 1913, page 468. 0.13395 is the area of the proportional segment of a circle of unit diameter and is found from a table of circular segments, after finding the height of the proportional segment by dividing the boiler diameter by the height of the steam space $\frac{15}{60} = 0.227$.)

Then the net cross-sectional area is

$$23.758 - 6.294 - 4.052 = 13.412 \text{ sq.ft.}$$

and the volume

$$13.412 \times 16 = 214.59 \text{ cu.ft.}$$

ENGINEERS' STUDY COURSE

Analysis of Coal—II.

Apparatus Required for Proximate Analysis

The following pieces of apparatus or their equivalent are required for making a proximate analysis:

1 chemist's balance (sensitive to 1 milligram)	$12 00
1 set of weights (50 grams to 1 milligram)	2 25
1 porcelain crucible with cover (15 c c capacity)	0 15
1 iron ring stand or iron tripod	0 25
1 Bunsen burner or gasoline blow torch, 25c or	2 75
1 desiccator (sulphuric acid) (4 in. in diameter)	1 25
1 lb. sulphuric acid (chemically pure)	0 30
1 drying oven	1 10
1 100-mesh sieve (small size)	1 40
1 mortar and pestle (porcelain)	0 35
2 porcelain insulated wire triangles (2-in.)	0 15
1 pair crucible tongs	0 35
1 coffee mill (cast iron)	1 15
	$23.45

Thus, you see, for a total cost of less than the price of a good steam-engine indicator any man can own the means of examining the coal used in his plant. And, although the indicator is a splendid instrument for effecting economy, it is even more important to examine into the character of the coal you purchase. If the ash or moisture content in a certain lot of coal is larger than normal, you should know it and take steps to avoid being "stuck" in a similar way again. If the character of the combustible part of the coal undergoes a marked change you should know it in order that the firing methods may, if necessary, be changed to suit.

It certainly is to the best interests (in every sense of the word) of every engineer operating a coal-burning plant, to analyze, if not a sample from every shipment of coal received, at least frequently enough to know with fair certainty whether the character of the coal changes, and to keep a record of all analyses together with the price of the coal from year to year for the purpose of future reference.

Now, the cost shown by my list may be reduced somewhat by substituting home-made apparatus and this point will be taken up as we discuss each individual piece.

The Balance

The most important piece of apparatus is the balance and the price given in the list is that of about the cheapest that can be used. More sensitive balances, capable of giving close results, would cost $25, $50, $75 or $100. But for the average power-plant requirements the $12 balance is satisfactory when used carefully. An actual picture of such a balance is seen in the assembly view, Fig. 2, and a sketch is given in Fig. 3.

The box rests on three legs, a stationary one at the rear and the two adjustable ones *A* at the front of the sides, by means of which the balance is leveled. The leveling in the present case must be done by placing a small spirit level on the top of the box, first extending left and right, then front and back, and adjusting the thumbscrews to suit. Some balances are fitted with a small plumb-bob for leveling, in which case the spirit level is unnecessary.

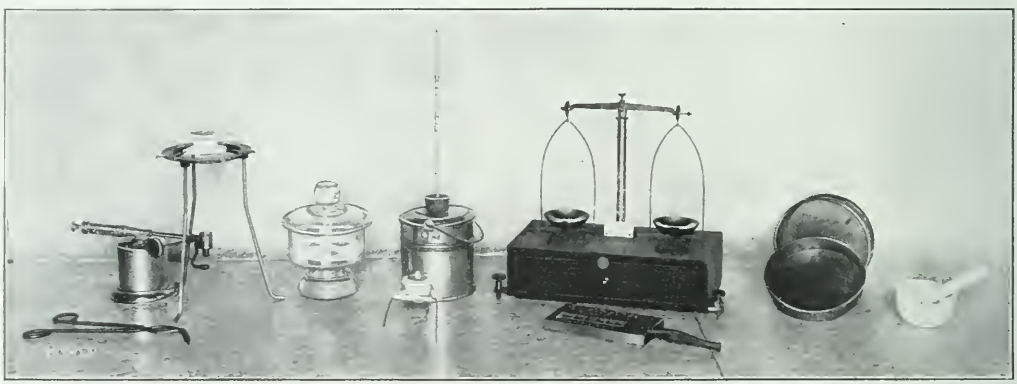


Fig. 2. Apparatus Required for Proximate Analysis

The balance beam, fitted with a small knife-edge shaft of hard steel at its middle, rests in the saddle *B*, at the top of the upright, which has V-shaped hard-steel bearings. A hard-steel knife-edge shaft at each end of the beam carries a stirrup with hard-steel V-shaped bearings from which the scales are hung. The scale pans *C* are removable. The saddle *B* is raised and lowered by means of the thumb-screw *C*; in the lowered position the scales rest on the box, as shown; in the raised, they clear the box by about ⅜ in. and the beam is thus free to swing and indicate whether the contents of the pans are equal in weight or not. The object of this arrangement is to make it more easy to load and unload the pans. The balance is so sensitive that if you attempted to lift one pan off or take out or put in a weight much greater than one gram, the other pan, unless first supported or steadied, would bang down on the box and perhaps upset whatever it contained or even dislocate its stirrup on the beam above. Thus, before greatly disturbing the equilibrium it

is convenient to lower the pans so that they rest on the box. Of course, when weighing, after an approximate balance has been established, the addition to or removal from the weight pan of a weight of 200 milligrams or less does not make the balance swing violently and the pans need not be lowered.

Before weighing, the balance should be tested by putting the empty pans in the scales, raising the beam and noticing whether the pointer D either remains on the center line of the scale E or swings an equal number of divisions to each side of the center line. If slight adjustment is necessary this can be made by turning the adjusting screw F one way or the other until the balance is correct. Best results are accomplished when the balance is placed where it is free from even the slightest air currents and uneven variations in temperature. The more expensive balances are housed in glass cases which have

The weights are based on the French or metric standards; the units used being grams and milligrams. The reason for using the French units instead of the English pounds, ounces, etc., is that as the French units are based on the decimal system they make calculation more simple. A gram equals about 0.035 of an ounce. One milligram equals $^1/_{1000}$ of a gram, and, hence to reduce grams to milligrams or *vice versa* it is simply a matter of adding the right number of ciphers or locating the decimal point. To illustrate, 526 milligrams equal 0.526 gram; 62 grams equal 62,000 milligrams; 13.27 grams equal 13,270 milligrams, etc.

One set of weights consists of one 50-gram, two 20-gram, one 10-gram, one 5-gram, two 2-gram, one 1-gram, one 500-milligram, two 200-milligram, one 100-milligram, one 50-milligram, two 20-milligram, one 10-milligram, one 5-milligram, two 2-milligram and one 1-milli-

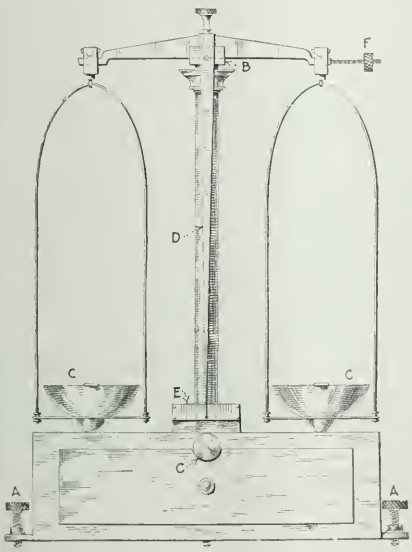


Fig. 3. Construction of Balance

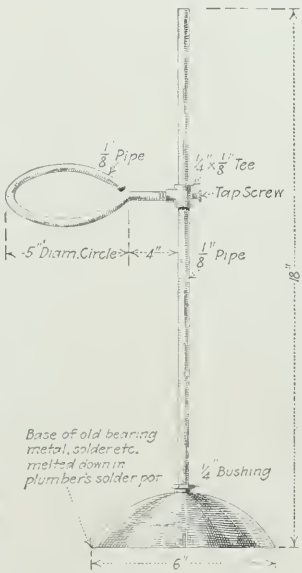


Fig. 4. Home-Made Ringstand

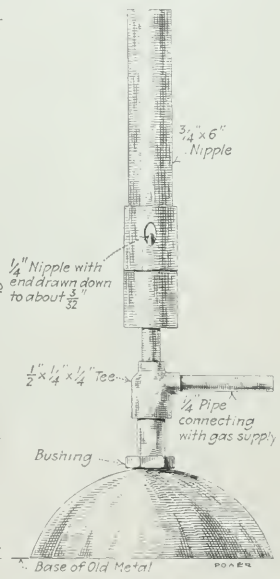

3/4" x 6" Nipple
1/4" Nipple with end drawn down to about 3/32"
1/2" x 1/4" x 1/4" Tee
1/4" Pipe connecting with gas supply
Bushing
Base of Old Metal

Fig. 5. Home-Made Bunsen Burner

fronts that slide up and down, the cases being closed when the final balancing is being tried. The ingenious man who wishes to get the best results with his $12 balance may build a glass case for it, constructing the case, of course, so that the thumb-screw C, for raising and lowering the scales, projects through the front and can be manipulated when the front is closed.

The weights are furnished in a special box which has compartments for each size and they should always be kept in the box. As soon as a weight is removed from the balance it should be placed directly in its compartment and not laid upon the table or anything else when it is in danger of becoming lost, dirty or damaged. A pair of forceps for handling the weights is furnished with every set and should always be used in preference to the bare fingers as moisture from the latter is liable to cause tarnishing or the accumulation of dirt, or other foreign matter.

gram weights, so that their range is from 1 milligram (0.001 of a gram) up to 111.11 grams advancing by milligrams.

Crucible

The crucible is the little vessel in which the sample of coal is heated. One made of porcelain will answer all our purposes. In ordering, specify the 15-c.c. size with lid. Its cost is so small that while a fair substitute could be devised it is not worth while doing so as the extra care required in handling would more than offset the saving effected.

The ring stand, shown in Fig. 4, can easily be made from ¼-in. iron pipe and fittings, and, being adjustable, it is more convenient to use than the tripod shown in Fig. 2.

If a good supply of gas is available (as in almost any city) a bunsen burner is the most convenient form of

heater to use. If not, a gasoline blow-torch, such as shown in Fig. 2, will be needed; or an ordinary plumber's or electrician's torch will do nicely. The latter, however, usually gives a horizontal flame and will have to be tilted a little in order to make the flame strike the oven or crucible to best effect.

A home-made bunsen burner as per Fig. 5 will give just as satisfactory results as a purchased burner. To regulate the air supply a loose sleeve is placed above the union on the $\frac{3}{4}$-in. nipple and is provided with four holes to match the holes in the nipple.

Desiccator

When the moisture has all been driven off from the sample of coal by the first heating and the sample is dry and still hot it would rapidly absorb moisture from the air if left exposed to it in that condition. And the same thing would happen after each subsequent heating if the sample were left exposed to the ordinary air.

Hence, the sample is transferred direct from the oven or from the tripod to the desiccator or drier to cool off

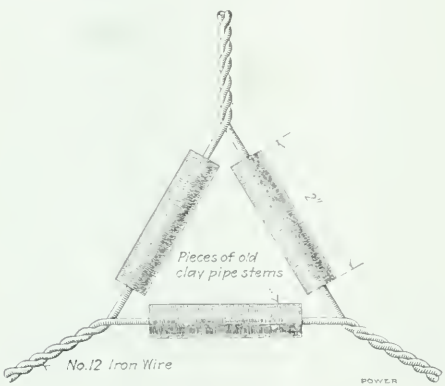


Fig. 6. Home-Made Triangles

before being weighed. The commonest form of desiccator is that shown in Fig. 2. It consists simply of a glass jar and lid; the joint between jar and lid being ground to an air-tight fit. The lower part or well of the desiccator is about quarter or half filled with pure sulphuric acid. The upper part contains a glass or porcelain tray upon which to set the crucible containing the sample of coal.

The principle of the desiccator is this: Sulphuric acid has a strong affinity for water or moisture. Hence, with an air-tight lid, what little moisture there is in the air entrapped in the desiccator is soon absorbed by the acid and the hot sample of coal does not get a chance to absorb any moisture and thus cause an error in the analysis.

One pound of chemically pure sulphuric acid (enough for use in the desiccator for a long time) can be purchased for 30c.; this includes the glass-stoppered bottle to contain it. How long the acid in the desiccator will remain effective depends on the manner in which it is used. If means are available for accurately weighing the acid or the desiccator before and after the acid has been put in, the acid may be renewed when the gain in weight is equal to 25 per cent. of the original weight of the acid. To illustrate, suppose $\frac{1}{4}$ lb. (or about 113 grams) of the dry acid were put into the desiccator and after six months or a year, the weight was found to be 5 oz. (a gain of 25 per cent.) it would then be advisable to refill the desiccator with fresh acid. If it is not convenient to check up the condition of the acid by weighing, it is safest to renew it about once a year.

Great caution must be used in handling sulphuric acid as it will attack or "eat away" the clothing, also iron, copper and many other metals. And, if it comes in contact with human flesh it causes a bad burn. Keep the bottle where it is not in danger of being broken and be sure that none of the acid is allowed to spill out of the desiccator. Also, never allow any water to come in contact with the acid as much heat is generated thereby and the acid might splatter on the face or hands. Always keep the lid on the desiccator to prevent the acid from absorbing moisture from the air and thus becoming weakened too soon.

Drying Oven

The drying oven is used for the first heating of the sample to determine the moisture content.

If you were to purchase a standard oven it would cost at least $5. The oven shown in Fig. 2 can be manufactured for $1.10 or even less. Secure a 1-qt. tin pail (about 4 in. in diameter by about $4\frac{1}{4}$ in. high) cost 10c. Punch a hole, about $1\frac{1}{4}$ in. in diameter, in the center of the lid. Next, secure a good sound cork to fit the hole and bore a hole in the cork so that the thermometer will fit in it snugly, as shown.

See that the lid of the pail fits loosely so that it can be removed without the necessity of holding the pail, as the latter will be hot and awkward to handle most of the time and the sample might be spilled if force is used. If necessary, cut off or bend in the flange on the lid. Punch one or two small holes ($\frac{1}{8}$ in. in diameter) in the side of the pail close to the bottom also one or two in the lid to provide for a small circulation of air.

Purchase a chemical thermometer having a range from zero to 200 deg. C., cost $1. Insert this in the cork, as shown in Fig. 2, so that the bulb projects into the pail about $1\frac{3}{4}$ in.

Bend down the ends of a porcelain-insulated wire triangle so as to form a little stand for the crucible, as shown in Fig. 2. Put this stand in the pail and place the pail on the ringstand or tripod over the burner and our home-made oven is ready for "business."

The next item on our list, the 100-mesh sieve, is desirable but not absolutely essential. It is used for sifting the sample before the analysis. If economy in first cost is imperative, the sample may be prepared without sifting, but extreme care should be used to crush the sample uniformly and as fine as possible.

The mortar and pestle, for crushing the sample, may also be dispensed with if desired; but the price is so small and they are so convenient that this is not recommended. If the sample is crushed with a hammer in an iron pot, on a sheet of iron, slab of stone or other hard surface, care must be taken that particles of incombustible foreign matter do not get mixed with the coal, thus causing an error in the analysis.

The next item on the list, the porcelain-insulated wire triangles, are used, one for supporting the crucible on the tripod or ringstand over the flame, the other, bent as just described, for supporting the crucible in the dry-

ing oven. Satisfactory home-made triangles may be made as shown in Fig. 6.

The crucible tongs, shown in Fig. 2, are used for handling the crucible and lid throughout the analysis. A pair of home-made tongs could be devised, but it is doubtful if the effort is worth while as they probably would not be as "handy" or as smooth working as a purchased pair.

The last item on the list, the coffee mill, is employed to coarsely grind the sample before it receives the final mixing and crushing. If an old coffee mill is available, so much the better, as it will answer just as well as a new one and the cost of the new one will be saved. It should be strong enough, however, to stand the service. One made of cast iron would be suitable.

⁂

Pumping under Difficulties

The photograph shows the pumping station at South Glens Falls, N. Y., just prior to the flooding of the pump and boiler rooms.

This little station is on the bank of the Hudson River and delivers water to a standpipe 18 ft. in diameter, 125 ft. high on a hill to the left and not shown in the photograph. This tank holds the only water supply for the town.

Thirty-six hours after the photograph was taken the water had risen level with the top of the "No admittance" sign between the door and window, and thus flooded the

PUMPING STATION THIRTY-SIX HOURS BEFORE WATER REACHED HIGHEST MARK

boiler room, putting out the fires. When the water began to rise rapidly the pumps were started so as to fill the standpipe and increase the supply available from the tank. The boilers are hand fired and use natural draft. The plant was kept in operation until the water rose so high in the ashpits that the draft became inadequate to burn the coal. The plant was out of commission for 36 hours and the town was without water for 17 hours.

The only real damage to the plant was the breaking of the stack at the uptake. This was caused by a log jam lodging against one of the guy wires, and pulling the stack over enough to break the uptake. Sheet asbestos and sheet tin wired around the break serve to give draft enough to operate the boilers. As soon as the water receded below the grates the fires were started

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Know anything about wabbling that you're not ashamed to tell? In the May 13 issue this question is propounded: "Shall we let the foot-pound wabble or vice versa?" As Prof. Kent says there's no need for its wabbling, shall we let it vice versa? Or just wriggle or turkey-trot? What's the difference between a wabble and a vice versa?

⁂

No, Eliphalet, we're under no obligation to climb genealogical trees and shake down any reader's ancestors. We will oblige by stating that there was an Eliphalet O'Reilly in the War of the Revolution. Here also are recorded a few more euphonious names that today would savor of lost motion: euphonious names that today would savor of last motion: Ebenezer Murphy, Ichabod O'Flanigan, Abel Kelley and Esau Sullivan. 'Twas Kelley that put over that stirring war-cry, Erin go unum e pluribus bragh, which freely translated means that the Irish stood united in the belief that God loves them!

⁂

"Seventy-five men and women were startled when the dynamo of the machine exploded," says the New York "Times." Startled? This announcement would startle a New York street-car horse, one of the most prepossessed beasts in captivity.

⁂

When you make a Kansas engineer believe that you say something when opening your mouth and you hit straight from the shoulder, and your slogan is "Fair play for us all"—you can be sure you're a man and a brother. Frank Thomas, supervisor of the Santa Fé Ry. apprentices, did just this thing at the Topeka convention, and the boys made him an honorary member of the N. A. S. E. "Any Tom, Dick or Harry can't be a good engineer," said Frank. "Yours is a profession requiring talent and brains."

Bully and some!

⁂

A weisenheimer is trying to scare us by saying there's 35,000,000 bacteria in a cubic inch of ice cream. That we should become disturbed! We're all chuck full of these things. We've carried 'em around so long that the wildest "bac." eats out of our hand. Some of you single chaps, though, might use the things as an argument when your best girl has you headed for the village ice-cream parlor.

⁂

"President Wilson would do well to train a few stationary engineers for his diplomatic posts abroad," writes T. F. White, over to Texas way. T. F. thinks that the s. eb's experience in managing subordinates and keeping persons grata with his bosses should ultimately fit him to cope with all questions of wars, stratagems and the unspeakable Turk.

⁂

STOP, LOOK, LISTEN!

By Billy Spills

Our well-intentioned correspondents are hereby warned that this spillway will soon slop over if it continues to be crowded by items on hints to mothers, physical ailments or patent devices. Your Uncle Spills is neither a diagnostician, a patent-attorney, an encyclopedia, nor—

Here, read two samples of this stuff for yourself:

Dear Billy: My husband thinks our baby will be a humorist when he grows up, as every little while he (the baby) has a pimple on his nose. Is a pimple a sign of humor?

MRS. BOYLE.

Friend Bill: I'm quitting engineering. Got a good thing if I can get it patented. It's a collar-button with a whistle on it. Am sending a blueprint so's you can get a line on it. What do you think of it? Have been experimenting with a hollow nut, but there's nothing in it

JOHN BUGG.

Mrs. Boyle's husband's baby's pimple is sure humorous. What he'll be when he grows up is beyond my ken; he might get rash before he grows up.

As for John Bugg's whistling collar-button, and his blueprint with a line on it, and his hollow nut—

Say, John, you stick to engineering or your folks will have to pay your board in a psychopathic ward and you'll be hearing that collar-button whistling through your hollow nut.

Gasoline Explosion in Power Plant

By L. Claire Hulbert

On May 7 the building of the Lapeer Gas-Electric Co., of Lapeer, Mich., was destroyed by an explosion and fire. As the firm name indicates the company supplied electric and gas service. The gas was made from gasoline which was stored in tanks under pressure.

The day engineer, who was alone in the building at the time, was responsible for the accident. He attempted to empty a drum of high-gravity gasoline without reducing the pressure to atmospheric before removing the stopper. The engineer's clothes were saturated with the gasoline and the room was immediately filled with vapor.

Fig. 1. Photograph Taken about 15 Min. after Explosion, Showing Damage to Wall

Fig. 2. Just after Explosion of a Drum of Gasoline

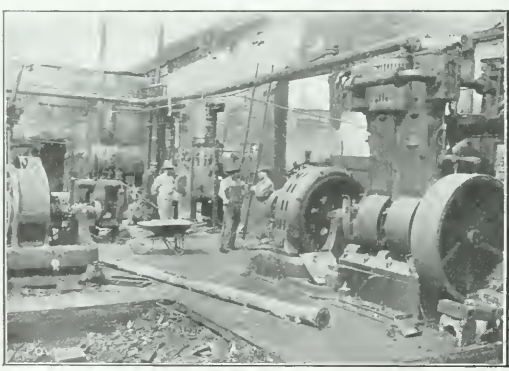


Fig. 3. Engine Room on the Morning after the Fire

Fig. 4. Destruction in Gas Room

Some of this must have penetrated through the fire wall to the boiler room adjoining, and the explosion followed. The entire wall of the gas room and the large plate-glass window of the office were blown out and flames filled the building from end to end. The engineer's clothes caught fire before he could escape, causing burns which resulted in his death a few hours later.

Several drums of gasoline exploded as the fire reached them. The bottom of one tank gave way and it ascended like a skyrocket about 200 ft. in the air. It landed on the sidewalk, where it is shown in the middle foreground of Figs. 1 and 2. Fig. 3 shows the engine room as it appeared after the fire, and Fig. 4 the gas room.

The company used every effort toward getting the plant in shape and were able to furnish light to their customers on Saturday, May 10, the third day after the accident.

*

Power Plant with a 5412-Foot Head

A water-power scheme of 5412-ft. head has not, heretofore, been heard of, but has been considered impracticable in technical circles. Mr. Boucher, of Lausanne, civil engineer, after whose plans many water-power schemes, with a comparatively high head have been already carried out, made it his aim, as a member of the board of Administration of the Societe d'Electro-Chimie, of Paris, to convert the water power of the Lake of Fully, near Martigny, in Canton Wallis, Switzerland, with such a high head as hitherto has never been used, namely, 5412 ft., into electric energy. The execution of this project has in the meantime been resolved upon, the orders for the necessary materials placed and the work commenced.

The most interesting question in connection with this scheme arose when deciding in what manner the pipe line should be constructed in order to withstand a pressure of 2343 lb. per sq.in. at the lower end. However, a most satisfactory as well as perfectly simple solution was found.

The pipe line in a length of about 2¾ miles consists of pipes with inside diameters of 19 11/16 in., and 23⅝ in.

and thicknesses of from $^{15}/_{64}$ in. to $1\frac{3}{32}$ in. The pipes of the upper section will be of the well-known water-gas, lap-welded type, whereas those of the lower part will be seamless.

The 15,000-hp. turbines will be built by Piccard, Pictet & Co., Geneva, the construction of the pipe line is in the hands of Thyssen & Co. at their Muelheim-Ruhr steel, plate and tube works.

Boiler Explosion Fatal

At noon, Tuesday, Apr. 22, the horizontal tubular boiler at the Thompson brick yard and sawmill, Mt. Pleasant, Mich., exploded, killing three men, and seriously injuring several other persons. William Thompson, owner of the mill and acting engineer, was instantly killed. The damaged mill is shown in Fig. 1. The boiler was about 30 years old and was formerly operated in a mill, and went through a fire when the mill was burned. The dimensions of the boiler were 50 in. by 11 ft., and it contained seventy 3-in. tubes, several of which had been leaking and were plugged. More were welded with questionable success. The shell was of $^{3}/_{8}$-in. iron when new, but it had corroded so badly in places that it was exceedingly thin. The force of the explosion was toward the rear, and the tubes, bent and twisted, were scattered over a space 200x100 ft. The dome, a part of the shell and the front head were thrown 300 ft., landing as shown in Fig. 2.

It is said that the boiler had long been in an unsafe condition and last season the owner installed a motor supplied with outside current to run the brick yard, but insisted on running the boiler for the sawmill because the sawdust and chips furnished cheap fuel.

It is reported that there had been trouble with the feed pump the day before the explosion. The safety valve started to blow just an instant before the explosion, which would indicate that overpressure was the cause. The boiler had received its share of patches, two of which are shown in Fig. 2. Fig. 3 shows the damage wrought by the explosion. The boiler was of the lap-joint type.

Fig. 1. Engine Room after the Explosion

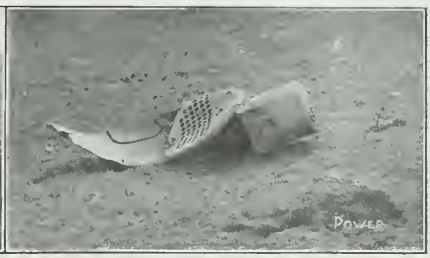


Fig. 2. Front Head and Dome

Fig. 3 Another View of the Damaged Mill

Clearance Measurement by Water

The following manner of determining the clearance space in engines is recommended by the American Society of Mechanical Engineers.

To measure the clearance by actual test, the engine is carefully set on the center, with the piston on the end where the measurement is to be taken. Assuming, for example, a Corliss engine, the best method is to remove the steam valve, so as to have access to the whole steam port, and then fill up the clearance space with water, which is poured into the open port through a funnel. The water is drawn from a receptacle containing a quantity previously measured. When the whole space, including the port, is completely filled, the quantity left in the receptacle is measured and the difference shows the

amount which has been poured in. The measurement can be easily made by weighing the water and the corresponding volume determined by calculation, making proper allowance for its temperature. The proportion required is the volume in cubic inches thus found, divided by the volume of the piston displacement, also in cubic inches, and the result expressed as a decimal. In the test care should be taken that no air is retained in the clearance space when it is filled with water.

The only difficulty in measuring the clearance in this way is that occurring when the exhaust valves and piston are not tight, and the water poured in, flows away and is lost. If the leakage is serious, no satisfactory measurement can be made, and it is better to depend upon the volume calculated from the drawing. If not too serious, however, an allowance can be made by observing the length of time consumed in pouring in the water; then, after a portion of the water has leaked out, fill up the space again, taking the time and measuring the quantity thus added, determining in this way the rate of leakage. Data will thus be obtained for the desired correction.

Repairs to a Reinforced-Concrete Chimney

An interesting description of repairs to a reinforced-concrete chimney was given by C. E. Smith in the May 8 issue of *Engineering News*.

The chimney, built in 1903, is 160 ft. high. The lower 60 ft. is composed of a double shell and the upper 100 ft. of a single shell, the entire chimney being reinforced horizontally and vertically by mild-steel T-bars. The horizontal bars are 1x1x⅛-in. bent circular and the vertical bars are 1¼x1¼x¼ in.

The inner shell of the lower portion is 4 in. thick and has an internal diameter of 5 ft. It is reinforced by horizontal circular T-bars 18 in. apart and vertical T-bars 16 in. apart. The outer shell of the lower portion is separated from the inner shell by a 4-in. air space. The outer shell is 8 in. thick and has an external diameter of 7 ft. 8 in. At the top of the double-shell section of the chimney the inner and outer shells merge, vents being left in the inner shell for purposes of expansion.

Above this portion extends 100 ft. of chimney having a single shell with an external diameter of 6 ft., the thickness of shell being 6 in. for the lower 45 ft., 5 in. for the next 30 ft. and 4 in. for the top 25 ft. In the fall of 1912 it was noticed that during severe winds the chimney gave out a grinding sound and chunks of concrete fell from its outer surface, creating considerable alarm among the employees having duties near the base of the stack.

Close inspection from the iron ladder attached to one side of the chimney and by telescope of the remaining surface, indicated that the entire upper portion, 100 ft. high, was cracked vertically and horizontally into a large number of rectangular slabs, the cracks being located along the lines of the reinforcement and that the cracks would soon become so large as to permit corroding influences to reach the thin reinforcing members, which would have resulted in the early collapse of the chimney.

On account of the fact that the plant is almost continually busy, it was decided to make repairs without taking the chimney out of service.

The upper edge of the chimney had deteriorated so badly and the concrete there was so shattered and loosened that it was considered unsafe to suspend a swinging platform from the top, so a temporary timber staging resting on the ground was erected around the chimney, reaching to the top, and bracing was so arranged that platforms could be placed at intervals of about 6 ft. From these platforms a very careful examination of the entire chimney was made.

It was found that the cracks were much larger and more open, and the chimney in much worse condition than was indicated by the preliminary examination. In many places the reinforcement was entirely exposed and had already deteriorated considerably by corrosion. It was decided to cover the entire 100-ft. upper portion with a reinforced-concrete shell 3 in. thick, and repairs were started immediately.

Before placing the reinforced-concrete shell all loose concrete that could be readily dislodged by a hand hammer was removed, the cracks and exposed reinforcement were brushed clean and all openings and cracks filled with grout. Deformed rods ⅜ in. in diameter were placed vertically 6 in. apart entirely around the chimney, the lower ends of these rods being set and grouted in holes drilled in the outer shell of the lower portion of the chimney. Deformed bars ⅜ in. in diameter were also bent around the chimney to form a spiral from top to bottom with 6-in. pitch. The rods were placed as nearly as possible 1½ in. from the outer surface of the chimney.

Four steel forms were used. Each lift consisted of two half-cylinders of No. 10 steel plates 3 ft. high stiffened top and bottom and at the ends by small angle iron in which bolts were placed to hold the sections together. The inside diameter of the forms when set up was 6 ft. 6 in.

The concrete was mixed "dry," to permit early removal of the forms, and was thoroughly tamped in place. Most of the concrete was placed when the temperature was slightly below freezing, but no precautions were taken to prevent freezing. As the chimney was in use throughout the work, having an external temperature of about 80 deg. F., the new concrete set rapidly and permitted the removal of the forms after 24 hr., which permitted the placing of about 12 ft. in height each day. The job cost about $2500.

Multiport Exhaust-Outlet Valve

A chart, showing the internal construction of the Cochrane multiport safety exhaust-outlet valve, has just been issued. The device can be used either as a back-pressure valve for exhaust-steam heating or drying systems, or as an atmospheric relief valve in connection with vacuum condensers. The distinguishing feature of this valve, which is made by the Harrison Safety Boiler Works, Seventeenth and Clearfield Sts., Philadelphia, Penn., is that instead of a large disk, there are a number of small disks, each held to its seat by an independent spring.

The tension upon the springs is adjusted by a movable pressure plate, the motion of which is limited to prevent overloading. The adjustment of the pressure plate can be accomplished by a handwheel on the outside of the casing, or may be controlled from a distance by rods, chains, electric motors, hydraulic pressure, etc.

Because of the lightness and small travel of the separate disks the valve operates quietly and a measure of safety is secured by having a number of disks instead of but one.

The New Allis-Chalmers Co.

On Apr. 16 the Allis-Chalmers Manufacturing Co. took over the properties and entire operation of the business of the Allis-Chalmers Co., which has been in the hands of a receiver. This change marks the end of the receivership and the commencement of the administration of the new company.

From Apr. 16 all business will be conducted by the Allis-Chalmers Manufacturing Co., which starts out under promising conditions. It will operate all departments as conducted by its predecessor and will carry out all contracts on hand and has no bonded indebtedness nor liabilities. In addition to all assets of the former company, the new one has over $4,000,000 additional cash for new working capital, raised through the recent reorganization.

The new company will continue to operate the large West Allis Works and Reliance Works at Milwaukee, the Chicago Works, and in addition will control the operations of the Bullock Electric Manufacturing Co., Cincinnati. Otto H. Falk, Milwaukee, who for the past year has been receiver, and under whose management the business has shown marked improvement, has been elected president of the new company. The general offices will be at Milwaukee.

All the properties are in good condition and the inventories and working capital on a sound basis. The engineering departments are well equipped and the lines of product turned out are of the highest quality. Under these conditions it is believed that with the present careful and intelligent management the operations will show substantial profits.

Nashville Wants a Boiler Works

The Nashville Industrial Bureau has gathered statistics showing that there are more than 300 boilers bought annually in Nashville for enterprises that use batteries of from one to six boilers. At present these must be purchased in other markets, and the fact that other towns and villages within 100 miles use many boilers and that materials for the manufacture of boilers may be shipped from the steel- and iron-producing fields promptly and cheaply, makes Nashville an ideal spot for a boiler factory of large proportions.

The state of Tennessee is noted for its friendship to home manufactories and Tennessee-made products, says the Bureau, and with this assurance of support, a big factory is sure to be a money-maker from the start is the unanimous opinion of long-sighted business men who have been interviewed on the subject.

The industrial bureau courts inquiry from anywhere, and assures anyone interested that its facts are authentic and that its tip that here is a splendid opportunity for a money-making investment are worthy of consideration. The bureau will gladly furnish further information to persons who care to investigate.

The field is not only a fine one already for such an industry, concludes the statement, but is becoming more so each year. New enterprises using steam are springing up at intervals, and will continue to come here, for Nashville is rapidly adding to her greatness as a manufacturing center.

School Notes

During the Easter holidays a party of about forty electrical engineering students of Sibley College, Cornell University, took a short three-day inspection trip. Thursday Friday and Saturday, Apr. 3, 4 and 5. The first day was spent in the General Electric Company's plant at Schenectady, the second in its plant at Pittsfield, and the third in New York City. At Schenectady, between seeing the sights in the morning and afternoon, the students were the guests of the company at luncheon, where the visit was made pleasant by making and renewing acquaintance with many Cornell alumni, many of whom are recent graduates. The itinerary of the trip did not permit staying over in Schenectady, so the men left early for Albany and thence for Pittsfield.

The next day they were the guests of the General Electric Company's officers in the Pittsfield plant. Here a regular program was planned by the company's men. The morning session was started with a meeting called to order by Mr. Toby, who introduced the various speakers. Mr. Insull, assistant general manager of works, whose son is an undergraduate in Sibley, and Mr. Toby gave short addresses of welcome, after which representatives from five of the departments gave short explanations of the work in them. These departments were then visited, after which a buffet lunch was served in the company's new club house. Following another meeting, during which the work in the other departments was explained, the rest of the plant was visited. These introductory talks added much to the understanding of the work being done. In the shops the spot welding, oxy-acetylene welding and cutting, and high-tension testing demonstrations were especially interesting.

The next day, Saturday, in New York the men visited the power plants of the Interboro Rapid Transit Co. on Fifty-Ninth St. the Edison Waterside stations and one of the railway substations. The party then broke up and the men proceeded to their homes or on individual sight-seeing trips.

NEW PUBLICATIONS

GAS POWER. By C. F. Hirshfeld and T. C. Ulbricht, respectively professor and instructor of power engineering, Sibley College, Cornell University. Published by John Wiley & Sons, New York, 1913. Cloth, 5x8 in.; 209 pages, illustrated. Price $1.25 net.

In this little book the authors have undertaken the difficult task of presenting the subject of gas power in non-technical language, their aim being to meet the needs of the manual training student and others who have not had the necesary technical training to comprehend the majority of works on internal combustion motors. Of course, it has been necessary to omit many of the theoretical considerations entering into the problems of design and the book is in no sense a complete treatise. Nevertheless, it should afford the reader a very good general idea of the subject.

Briefly, the items covered are fuels, the development of internal combustion engines, the four- and two-stroke cycles, methods of cooling, governing, ignition systems, carburetors, gas producers, types of gas, gasoline and oil engines, the rating of internal combustion engines and their performance.

Representative apparatus of each type is described and the illustrations are well chosen.

STEAM BOILERS. By Cecil H. Peabody and Edward F. Miller. Third edition revised and enlarged. New York. John Wiley & Sons. Pp. 543 6x9-in.; illustrated; cloth. Price, $4.

The authors, professors of naval architecture and marine engineering and of steam engineering, respectively, of the Massachusetts Institute of Technology, are well recognized authorities upon the subject of steam boilers, and their book, which made its first appearance in 1897, soon took a foremost place in the literature of the subject. In the third edition, which has just appeared, the subjects of mechanical stokers, economizers and steam piping have been treated at considerable length, and the use and calculation of induced draft fans quite fully explained. Much new material on chimney draft, the result of work extending over a period of years, has been added, as has also a chapter on Coal Handling and Coal Handling Machinery. The chapter on Combustion has been extended to cover oil burning and to include the most recent analyses of American coals, together with a detailed description of coal calorimetry, as applied to the determination of the heating value of coal purchased on a heat unit basis. The chapters on Staying, Riveted Joints and Boiler Testing have been extended; in fact, hardly a chapter in the book has not been amplified to some extent, and the number of illustrations has been nearly doubled.

Matheson Joint Pipe

The National Tube Co., Pittsburgh, Penn., has issued an attractive booklet under the above title. It deals with the manufacturing advantages and use of the Matheson joint pipe, which is suitable for use in mines, water-works, irrigation systems, hydro-electric plants, compressed air or gas transmission lines, or wherever a lead joint is suitable with pipe lines ranging from 2 to 30 in. in diameter. The booklet contains 40 pages and brings out a number of new features not published in the first edition.

Kentucky N. A. S. E. Convention

The first of the Middle West state conventions of the National Association of Stationary Engineers, was held in Hopkinsville, Ky., on May 7, 8 and 9, this being Kentucky's eleventh annual convention.

The exhibit at the Armory was opened at 8 p.m., Wednesday, and an address of welcome made by W. A. Wilgus. H. R. Anness, chairman of the executive committee of the Central States Exhibitors' Association, responded in the absence of President W. L. Osborne.

The preliminary session was opened at 10 a.m., Thursday, by State President J. L. Shrode, who, after the invocation by the Rev. A. R. Kasey, introduced Mayor Meacham to welcome the delegates and visitors. National Secretary Ryan made the response.

The afternoon session was devoted to committee reports and routine business.

In the evening Frederick L. Ray gave an illustrated lecture on "Gas Engines" at the Avalon, after which the exhibits of the supply houses were inspected.

At the election on Friday morning the following were chosen for office for the coming year: C. Carroll, Louisville, president; George J. Jake, Hopkinsville, vice-president; A. J. Pohl, Louisville, secretary; Edward Kochenrath, Louisville, treasurer; R. A. Quinn, Henderson, conductor; W. L. Franks, Owensboro, doorkeeper; J. L. Shrode, state deputy.

After the installation the delegates and guests went to Campbell's Cave, where a barbecue was held until 5 p.m. In the evening, a reunion took place at the Elks Club, where old acquaintances were revived and new ones formed.

The next annual convention will be held in Louisville.

SOCIETY NOTES

The first annual dinner and entertainment of the New England Association of Commercial Engineers was held on the evening of May 17, at the Revere House, Boston. Among the guests were the mayor of Boston, John F. Fitzgerald, and Walter G. Diman, mechanical engineer, Manchester N. H. President Albert C. Ashton was the toastmaster.

PERSONALS

E. G. Lender, who for several years was chief engineer for the Prudential Insurance Co., Newark, sailed for Germany recently.

S. M. Reid, formerly chief engineer for the Rothschild Realty Co., at 98 Fifth Ave., New York City, has resigned to accept the position of chief engineer of the Continental Paper Co., Bogota, N. J.

Thomas F. Marshall, after 20 years of service, has retired as superintendent of the operating department of the Toronto (Ont.) Electric Light Co., Ltd. In token of the esteem with which he was held by the members of the operating department he was presented a leather couch.

OBITUARY

DENNIS KILLERLANE

Dennis Killerlane, a retired engineer and boiler maker, head of Killerlane & Ryder, on First St., died on Sunday, May 18, at his home, 983 Bergen St., Brooklyn, in his seventy-sixth year. He was an old member of the Maritime Exchange and was well known in shipping circles. A sister, Miss Mary Killerlane, survives him.

⁂

When the Pennsylvania R.R. intended to change its specifications for boiler plate many years ago, it was stated at the Sixth Congress of International Association for Testing Materials it was the custom, as far back as 31 years ago, that from all worn-out boilers test pieces were taken and retested. Original duplicate testpieces from the new sheets were laid away, and when the worn-out firebox sheets were returned to the testing department the original duplicates were searched for and tested in comparison with the worn-out plate. This practice was carried on for 13 years, and these tests invariably have shown: (1) That, as far as it can be traced, the effect of the heat on the boiler sheet reduced any internal stresses due to the rolling; and (2) that whatever defects are found could almost invariably be traced to mechanical defects in the shop, in bending in flanging, in riveting, in drifting the rivet holes cold, and these effects then made their appearance by and through overstrain.

⁂

The energetic fight being made for new business by the Quebec Railway, Light & Power Co. and the Dorchester Electric Co., of Quebec, is reflected in the reduction of rates made by the former company from 15c. to7c. per kw.-hr. The Dorchester Electric Co. announces its intention of meeting the cut by making its base rate for energy 6c. per kw.-hr.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Milo Electric Light Co. is making preliminary arrangements for the installation of additional equipment in its power plant at Milo, Maine. Julian d'Este, Milo, is purchasing agent.

Arthus W. Dwyer is interested in the installation of an electric system at Paxton, Mass.

The installation of additional equipment in the municipal electric-light plant at East Norwalk, Conn., is under consideration. Fred H. Bergen is superintendent of the plant.

Plans are being prepared by the Cohoes Electric Light Co. for the construction of a power plant on the Mohawk River, near Cohoes, N. Y. Estimated cost, $1,000,000. Bids for the work will be received at the New York office of the company, 2 Rector St.

SOUTHERN STATES

Preliminary arrangements are being made for the reconstruction of the municipal electric-light plant and water system at Orangeburg, S. C. L. H. Wanamaker is city clerk.

Plans are being considered for the installation of additional equipment in the municipal electric-light plant at Statesboro, Ga. D. L. Gould is manager of the plant.

Plans are being considered for the installation of new equipment in the municipal electric-light plant at Waynesboro, Ga. J. C. Andrews is superintendent of the plant.

Plans are being considered by the Leesburg Ice Co., Leesburg, Fla., for the installation of additional equipment in its electric-light plant to double the capacity. J. Y. Clark is president.

The proposition to issue bonds for the construction of a municipal electric-light plant is under consideration by the citizens of Panama City, Fla.

Plans are being prepared by the Vivian Oil Co., Vivian, La., for the construction of an electric-light plant to cost $50,000.

The city council of Monterey, Tenn., has granted a franchise to J. T. Price and associates for the construction of an electric-light plant.

The Kentucky Utilities Co. will install additional equipment in its power plant at Somerset, Ky. T. J. Spragle is general manager.

CENTRAL STATES

At an election to be held soon the proposition to issue $110,000 in bonds for the construction of a municipal electric-light plant at Barberton, Ohio, will be submitted to the voters. W. S. Mitchell is mayor.

Bids will be received by W. J. Springborn, director of public service, Cleveland, Ohio, until May 27, for furnishing generators and converters and electric traveling cranes for the municipal electric-light plant.

B. F. Hewitt, consulting engineer, Jefferson, Ohio, is preparing plans for the construction of a municipal electric-light plant and water system at Cortland, Ohio.

The Consumers' Power Co. is considering plans for the improvement and extension of its system in Cadillac, Mich., and vicinity. W. A. Foote, Jackson, Mich., is president.

Plans are being considered for the purchase of additional equipment for the municipal electric-light plant at Petoskey Mich. J. W. Lovelace is manager of the plant.

The Central Illinois Public Service Co. has purchased the municipal electric-light plant at Girard, Ill. Plans are being considered by the new owners for the improvement of the plant.

WEST OF THE MISSISSIPPI

Mason & Mason have been granted a franchise to construct and operate an electric-light plant at Alton, Iowa.

The construction of a municipal electric-light plant at Russell, Iowa, is under consideration.

The citizens of Argonia, Kan., will soon hold an election to vote on the proposition to issue $25,000 in bonds for the construction of a municipal electric-light plant and water system. Rollins & Westover, Midland Bldg., Kansas City, Mo., are consulting engineers.

The proposition to issue $11,000 in bonds for the construction of a municipal electric-light plant at Howard, Kan., is under consideration.

POWER

Vol. 37 NEW YORK, JUNE 3, 1913 No. 22

HIS SURE DEFENSE

Coal and Ash Handling at Lake Shore Plant

By A. D. Williams

SYNOPSIS—In the Mar. 18 and Apr. 15 issues, respectively, were described the general features and the condensing system at this new plant of the Cleveland Electric Illuminating Co. The present article, dealing with the coal- and ash-handling system, brings out some new departures in this line and also shows that great care has been taken to prevent any interference in the plant operation from this source.

The coal-handling plant installed at the Lake Shore generating plant, at Cleveland, presents a departure from previous practice in similar locations. No provision has been made for running railroad cars containing coal directly over the bunkers and a very large storage capacity has been provided at the top of the bluff. The capacity of the bunkers over the boilers, however, has been made sufficient to cover any temporary breakdown in the conveying system. This arrangement results in a considerable reduction in the weight of the boiler-room steelwork.

All coal is delivered in cars and the plant is so arranged that train-load shipments can be cared for readily. Several thousand feet of track room are provided and these tracks are so laid out and connected that a number of cars may be unloaded at one time. A 3150-cu.ft. track hopper with grizzly and a 150-ton track scales are arranged so that coal may be delivered direct from cars to the conveyors feeding the boiler-room bunkers. An unloading trough 540 ft. long runs parallel with the reserve coal-storage pile under the gantry crane, which gives room to dump 15 hopper-bottom cars at one time. A shifting locomotive owned by the company renders it independent of those vexatious delays in handling cars in the yard which result from dependence upon the railroad for such service.

Storage capacity in the yard is provided for over 23,000 tons of coal, enough to run the plant a little over one month, the bunkers over the boilers will hold approximately five days' supply, and in an emergency sufficient coal could be stored to operate the plant several months. The storage yard is covered by a Brown Hoist gantry crane (see Fig. 1) having a span of 180 ft., and a 37-ft. cantilever extension covers two tracks, in addition to the one over the unloading trough. This machine is equipped with a 2-ton clam-shell bucket. Normally, coal is lifted from the unloading trough to the stock pile or from the stock pile to hopper-bottom cars, which are shifted to the scale and track hopper for supplying the boilers. In this work the crane is not shifted very frequently on its runway; hence the bridge travel of 200 ft. per min. is operated by the 112-hp. hoisting motor. The bucket-hoisting speed is 200 ft. per min. and the trolley speed 1000 ft. per min., the latter operated by a 52-hp. motor. These motors run on 230-volt, three-phase, 60-cycle current and are controlled from the operator's cabin.

Fig. 1. Gantry Crane over Storage Yard

The 150-ton track scale, Fig. 2, over the receiving hopper is so located that all coal coming into the plant, either for storage or immediate consumption, can be weighed. If intended for the bunkers, the coal is dumped into the track hopper from which it passes through plunger feeders to Bartlett & Snow four-roll coal crushers, Fig. 3, and thence to the inclined conveyor belt, elevating it to the upper portion of the boiler room. The crushers and feeders are installed in duplicate, either one of the pair being of sufficient capacity to cover ordinary demands. A bypass for fine coal is provided so that the crushers will not become choked. This limits their service to the crushing of the larger lumps. The track hopper and crushers are installed in a pit at the top of the bluff.

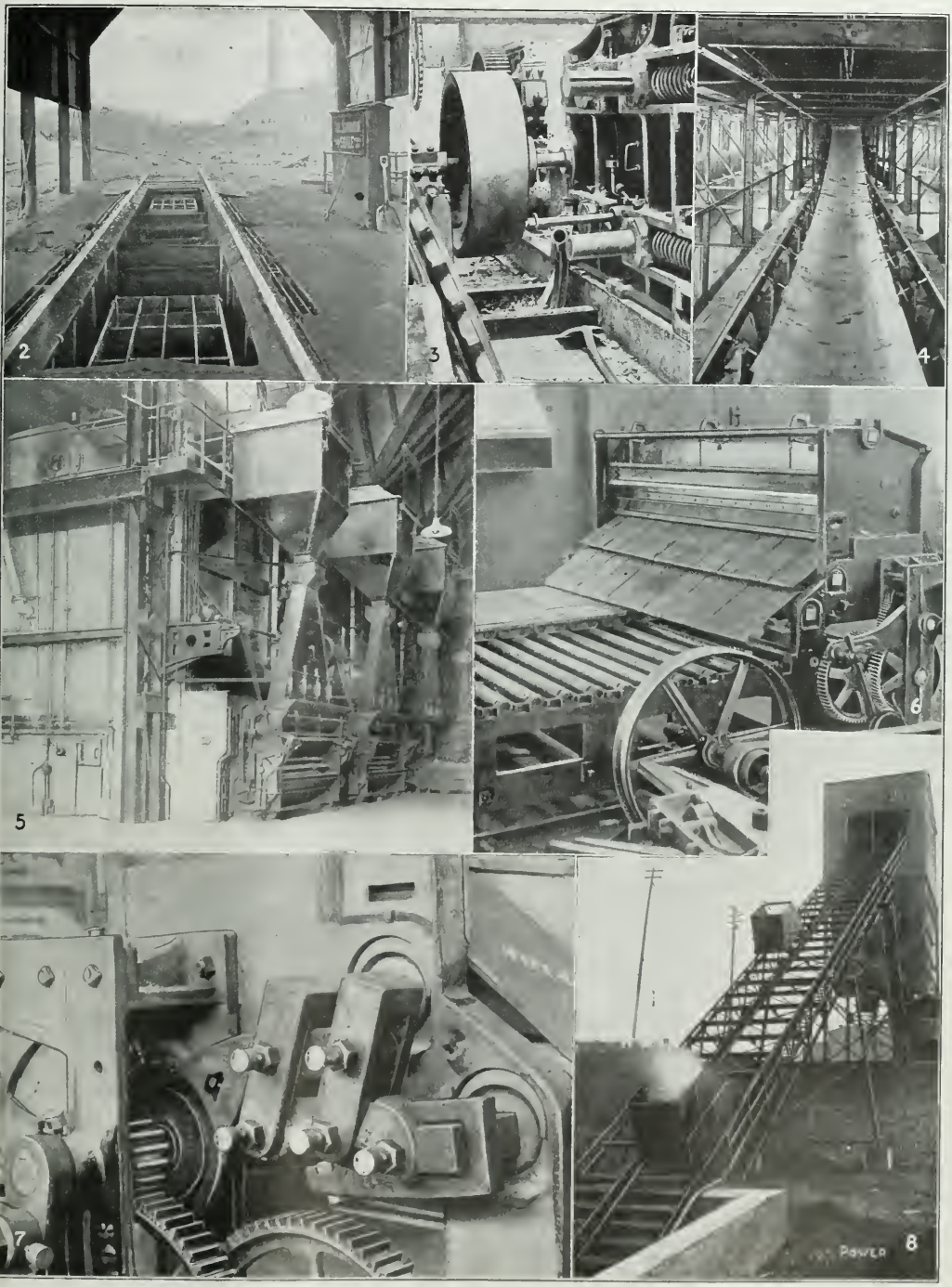


FIG. 2. TRUCK SCALES. FIG. 3. FOUR-ROLL CRUSHERS FIG. 4. BELT CONVEYOR. FIG. 5. WEIGHING HOPPERS IN FRONT OF BOILERS. FIG. 6. CHAIN-GRATE STOKER. FIG. 7. AGITATING MECHANISM OF STOKER. FIG. 8. SKIP AND ASH-STORAGE BIN.

A 30-in. conveyor belt with an inclination of 13 deg. raises the coal from below the crushers to a conveyor gallery on the south side of the boiler room and discharges either to the No. 1 bunker conveyor or to a distributing conveyor, which carries the coal to any one of the other bunker conveyors. The bunker conveyors and the distributing conveyor at right angles with them are 30-in. belts; one of these is shown in Fig. 4. The tripper on the latter is hand propelled as it is shifted from bunker to bunker only as it becomes necessary to supply coal to them. The trippers on the bunker conveyors are of the traveling type with reversing stops which can be set to limit the travel of the tripper to that portion of the bunker in which it is desired to distribute the coal.

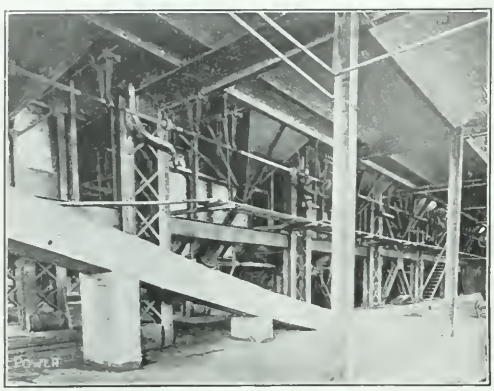


FIG. 9. ASH HOPPERS

The power consumed by these conveyors is given by their builders as follows:

	Horsepower at Motors		Load in Tons per hour
	Light	Loaded	
Inclined conveyor, 13-degree slope, 302 ft	..	23 5	162
		36 0	277
Distributing conveyor, 250 ft. long	6 8	12 2	242
Bunker conveyor, 200 ft. long	6.2	9.8	217

The concrete-lined bunkers above the boiler-firing aisles, provided for holding a few days' supply, have hopper bottoms and gates over each boiler. The west bunker, No. 1, serving a single row of boilers, has a capacity of 1000 tons, and the other bunkers 2000 tons each, the latter serving to supply two rows of boilers. This gives an immediate supply over each boiler of about 100 tons. From the bunker the coal flows by gravity into a weighing hopper, Fig. 5, holding 5 tons, from the bottom of which the coal flows into the spreader chute leading to the stoker.

The Green chain-grate stokers in this plant have been especially designed for use with caking or semi-caking coals. They differ from the usual construction in having an inclined agitating foreplate, Fig. 6, upon which the coal flows from the stoker hopper. This foreplate consists of two leaves, the lower edge of the upper lapping the lower and the lower edge of the bottom leaf resting upon the chain grate. These two leaves have a reciprocating motion, the upper moving forward as the lower is drawn back; the agitating mechanism is shown in Fig. 7. The igniting arch is immediately over the foreplate and the continual agitation of the fuel bed at this point prevents caking and hastens the driving off of volatile combustibles, which are drawn forward over the incandescent bed of coal. These stokers have a grate area of about 110 sq.ft. each, and their rate of grate travel can be adjusted to suit the demand, up to a maximum travel of 10 in. per min. The rate of combustion ranges from a normal value of 20 lb. of coal per square foot per hour to 40 lb. This latter rate, however, has been exceeded when forcing the boilers, the maximum under these conditions approximating 65 lb.

There are two hoppers below each boiler. The rear one, for the ashes, of ferroinclave and concrete, below the rear 6 ft. of the grate, has a double-hopper bottom and gates for discharging the ashes into an electric larry. A plate-steel hopper, Fig. 9, below the front 5 ft. of the stoker has a spout and gate that discharges between the two gates of the ash hopper. This steel hopper is designed to recover the partially burnt coal that falls through the grate.

The larry for the ashes runs on tracks laid on the basement floor below each row of boilers and connecting with two cross tracks close to the south side of the plant, running over a hopper from which the ashes can be discharged into a skip for raising them to an ash-storage bin located at the top of the bluff; see Fig. 8. This ash bin, which is of the parabolic suspension type, is about 200 ft. south of the plant and its top is 50 ft. above the tracks at the top of the bluff, making the total lift of the

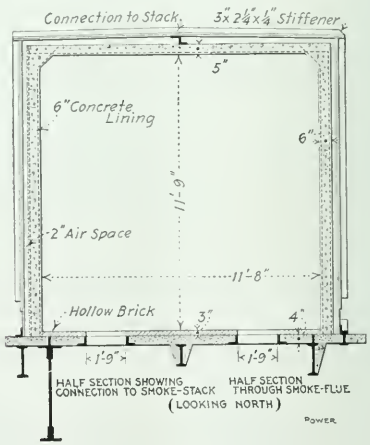


FIG. 10. SECTION THROUGH FLUE

skips about 135 ft. Each of the skips is of 200 cu.ft. capacity, and the skip hoist is of the automatic counterbalanced type, the cars dumping at the top of their run. Electrically operated discharge gates are provided for loading cars; these grates are fitted with steam-thawing nozzles and coils for use in cold weather.

The boilers are of the Stirling type with a Foster superheater having 800 sq.ft. of heating surface located in the second pass. The gases of combustion are drawn forward over the bed of coals on the stoker under a combustion arch and through special baffling designed by John Wolff, steam superintendent of the Cleveland Electric Illuminating Co. The boiler uptakes to the smoke flues are short and direct; 17.5 sq.ft. of area for each boiler. These

connect with the main smoke flue through asbestos-packed slip joints. The main smoke flue is of plate steel lined with reinforced concrete on the top and sides and paved with brick; see Fig. 10. Two flues connect with each chimney, each flue carrying the gases away from eight boilers and two boiler uptakes enter the bottom of the stack.

The chimneys are of steel plate lined with brick, the shaft being 216 ft. high and 18 ft. 6 in. diameter inside the lining; the height above the grates is 246 ft. Each chimney is designed to carry off the gases from 18 boilers. These chimneys are supported upon heavy girders carried by the building columns, which at this point are tower braced to carry the wind reactions to the foundations. The tops of these chimneys are about 270 ft. above lake level.

Two 14 and 10.5 by 18 Hughes duplex pumps supply makeup water to the boiler-feed line. This and the condensate from the turbines forms the boiler-water supply. This water passes through six-pass feed-water heaters having 1200 sq.ft. of heating surface for each unit. Each double row of boilers is supplied through three feed lines, one in the center with taps to both rows of boilers. A second feed line runs under the front end of the boilers in each row and serves only the single row. Each of these lines is metered by a venturi meter, which indicates the rate of flow, and also the total flow. Taps from these pipes enter the rear drums of the boilers the water in each case passing through a check valve and a gate valve on top of the boilers. This duplex-feeding system is designed to avoid any possibility of interrupting the service from a boiler through trouble with the feed lines; the layout is shown in Fig. 11.

The steam from the boilers passes through the superheaters, which are designed to superheat 15,250 lb. of steam per hour at 215 lb. pressure to 100 deg. F. In actual service much better results than this have been attained. The pitot orifice of a General Electric indicating steam meter is inserted in the superheater outlet just below the nonreturn stop valve and gate valve in the boiler connection to the steam line.

The blowoff outlets, two to each boiler, pass down through the floor to a blowoff header to which they make Y-connections. No blowoff tank is provided, the water being discharged directly into Lake Erie.

Cleveland Railway to Purchase Its Power

The purchase of street-railway power has been undertaken by the Cleveland (Ohio) Ry. Co., which is giving up the generation of its own electrical energy. It is under contract now to purchase 11,000-volt, three-phase, 60-cycle power from the Cleveland Electric Illuminating Co. This will be supplied to four substations equipped with rotary converters of special design, and storage batteries. The initial equipment of these stations will aggregate 15,500 kw. converter capacity with a possibility of increasing this to 25,000 kw.

Graphical and numerical records are to be kept by the substation employees, and forwarded to the railway company's power department each day for totalizing. As an aid to efficient operation the substation records will also show plotted the capacity of machines running at each hour, so that it will be evident what approach is obtained to full load on the equipment in service.

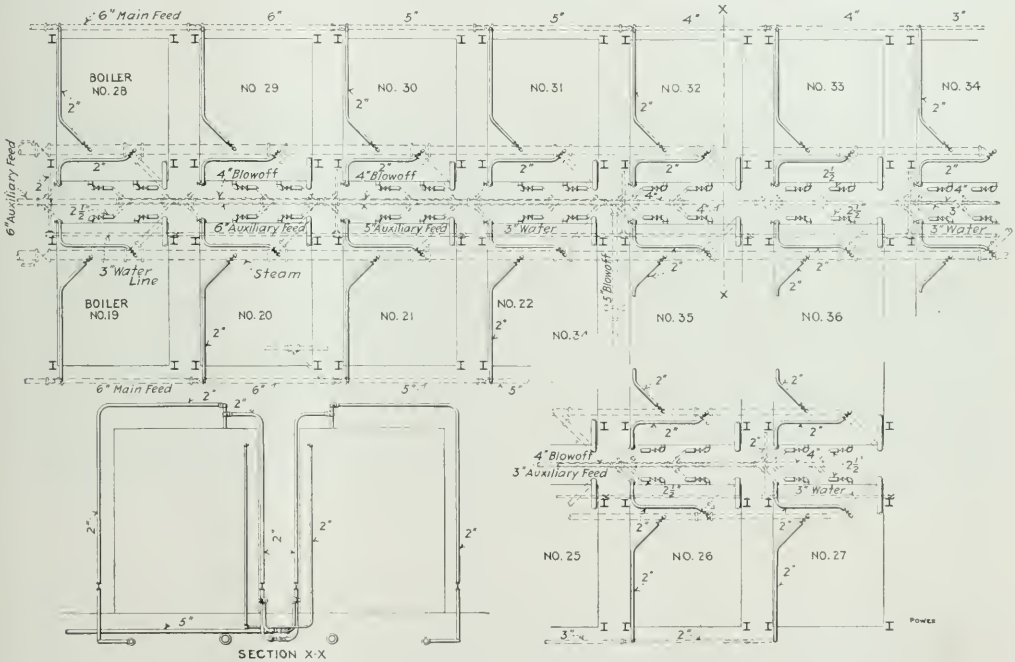


Fig. 11. Boiler-Feed System

Training Engineers at Yale

By Thomas Wilson

SYNOPSIS—Methods of training and the equipment of the laboratory. A testing floor facilitates the exchange of machines, and an interesting feature is the provision for transporting the smaller machines and apparatus to the rostrum of the lecture room.

Within the last 25 years, the development in engineering has been rapid and far reaching. New fields, better methods and improved machines have followed each other so rapidly that it has become difficult to keep pace with the times. In training students to enter this field, a corresponding advance has been required, and to crowd in all the information and training required in the brief four years allotted to a course, has become a serious problem. In fact, it is impossible to give the student very much of the information necessary to an engineer of today. A thorough grounding in fundamentals and engineering methods of analysis rather than the acquirement of a large number of facts appears to be the aim of modern schools.

Nevertheless, some knowledge of modern manufacturing, new types of machinery and methods of conducting tests must be imparted. It has been the policy in colleges of engineering and technical schools to equip their laboratories with all the machinery that they could afford to buy or induce some manufacturer to give them. These machines, and the general equipment, were permanently installed, and used year after year by the students. If there was space for additional equipment and money for its purchase, new equipment was added. It is easy to see that much of the equipment must soon become antiquated, and the laboratory filled with out-of-date machinery. The wisdom of such a course depends somewhat on geographical location. Where the student has little or no opportunity to gain previous or simultaneous experience in the vacation period with engineering practice, and the laboratory is far removed from an industrial center, the old policy is perhaps the better way. Even if the machine is out of date, the experience gained in running or testing it may be of some advantage in a professional career.

In New England, the great industrial center of the country, where machines of all kinds and of the latest types are readily accessible for testing or inspection, there is not so much need for a laboratory filled with permanent equipment. Of the prominent instructors in mechanical engineering in this country, Prof. L. P. Breckenridge, of the Sheffield Scientific School of Yale, was the first to break away from the older plan, and arrange a laboratory which would always have equipment of the latest design. The opportunity came when he was called to Yale and had the privilege of laying out in 1911 the Mason Laboratory of Mechanical Engineering. One of its prominent features is the testing floor, on which machines of all descriptions can be readily mounted or removed. A few standard machines, such as a Corliss engine and a steam-turbine generating unit, used for lighting the building, have been permanently mounted, but the general policy is to arrange for a loan of various types of machines for one or two years. They are then returned to the maker and a later machine of the same, or perhaps another design, takes its place. With a testing floor served by a 10-ton crane, the exchange is easy, and the students get the benefit of a variety. In addition to the many types of engines, pumps, fans, small boilers, etc., automatic machines of the latest design, with their variety of products, are brought in for a period of two weeks, and are usually accompanied by an expert demonstrator from the factory where the machines are made. In the course of a year, there is opportunity to show several machines of different types, so that during his training the student becomes familiar with the latest and best in machinery.

A carefully planned three weeks' course each year in shop visiting supplements the work. The students get valuable ideas of manufacturing methods, and these visits together with the excellent manual training now given in high schools in the East and their work in vacations in the numerous shops in New England, serve the purpose nearly, if not quite, as well as an extended course in shop training. In these days of progress, most everything is specialized, and it would be impossible to give the student a thorough training in all branches. In most cases a working knowledge of the line he is to follow must be gained after the period of instruction.

In the laboratory, there is a fairly complete equipment of small, self-contained machines, such as pumps, gas engines, small high-speed steam engines, a suction gas-producer outfit, testing machines of the Riehle and Olsen types, varying in capacity from 50 to 200,000 lb., steam traps, condensers, a Pelton waterwheel, a Uehling combined pyrometer and CO_2 recorder, heating boilers, a ventilating fan, tempering coils, and the like. A full line of scientific instruments and facilities for testing have been provided, to test the machines and apparatus in the laboratory, those that may be sent in for the purpose, and for power-plant tests of all kinds carried on outside the laboratory.

A feature of special interest is the provision made for taking small machines from the testing floor to the lecture room. They are first picked up by the 10-ton traveling crane serving the main floor, and delivered on the gallery platform at the entrance to the lecture room on the second floor. From here a 2-ton hand crane on a trolley rail carries the machine or apparatus onto the rostrum, where it is placed on exhibition or taken apart, as desired. Instead of the sketch or lantern slide the actual machine is often at hand to illustrate a lecture. The advantages of such a plan will be realized. The lecture room itself is a model of convenience. Much attention has been given to ventilation and lighting.

The general arrangement and construction of the building was made plain in our issue of Feb. 7, 1911, so that a repetition will not here be necessary. The purpose of the present article was to outline the equipment and the methods of training, and while doing so, it will interest many to learn that besides training the undergraduate and giving excellent opportunities for post-graduate work, there are plans forming to conduct coöperative industrial research work, such as is carried on in many of the Ger-

FIG. 1. MASON LABORATORY OF MECHANICAL ENGINEERING

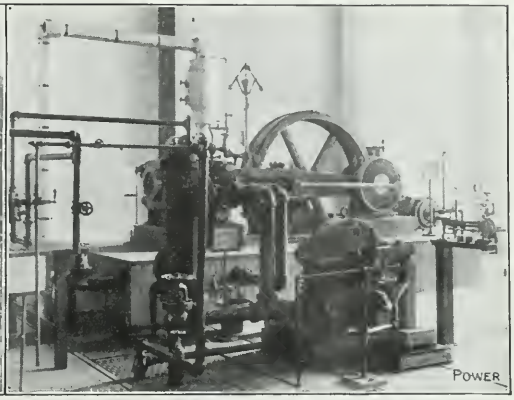


FIG. 2. AN OLD CORLISS AND A NEW TERRY TURBINE, BOTH RATED AT 40 HP.

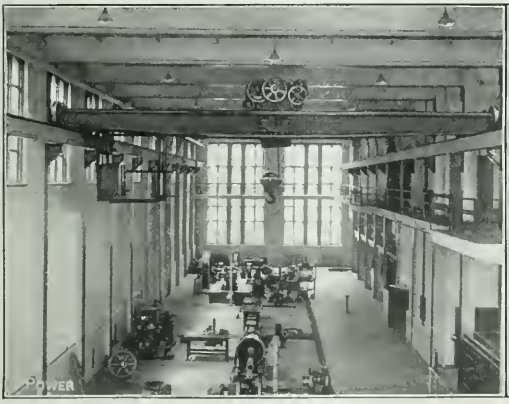


FIG. 3. PORTION OF TESTING FLOOR

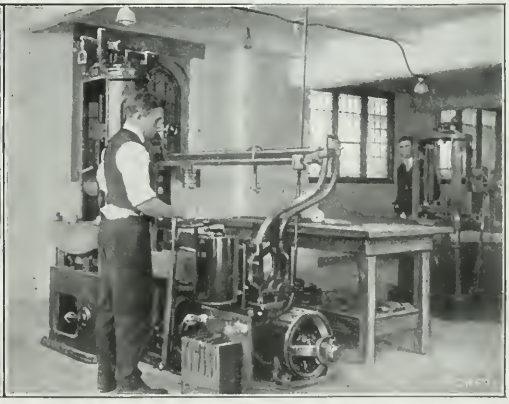


FIG. 4. ONE OF THE RIEHLE TESTING MACHINES

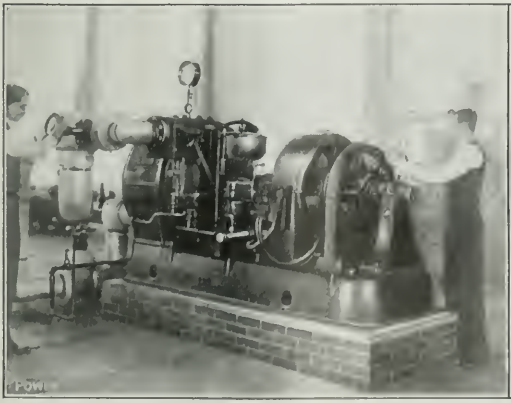


FIG. 5. CURTIS TURBO-GENERATOR SET

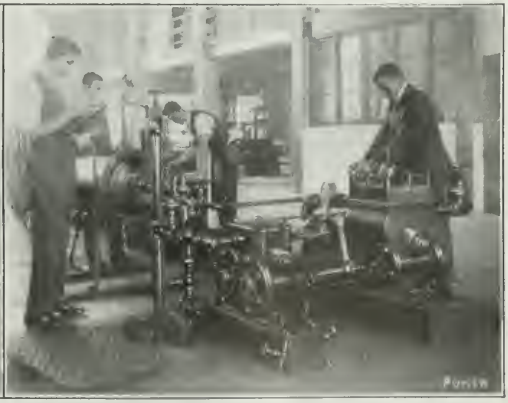


FIG. 6. DEANE STEAM PUMP

man technical schools as well as in the experiment stations of various state universities in this country. As the laboratory has only recently been completed, not much as yet has been accomplished in this line. At present, some work is being done on the domestic fuel problems of New England. A number of heating boilers, loaned by the makers, have been fitted up for testing the different kinds of fuel and economic methods of burning. Some testing work for the brass, copper and alloy interests is also on foot, and, in the course of time, it is expected that this phase of coöperative testing work will be of great assistance to engineering and industrial interests throughout New England.

The recent expansion of the engineering side of the work of the Sheffield Scientific School at Yale seems to promise some interesting and valuable developments. Science and engineering must more and more help each other. Yale is located in the midst of industries, and it would be only natural that science, engineering and industries should coöperate to the advantage of each.

A German Soot and Cinder Arrester

By Otto E. Trautmann

SYNOPSIS—A water spray and slag-cinder filter combination so effective that no black smoke, soot or cinders are emitted. White cloth held some time over the stack is only slightly discolored.

As methods of abatment of the smoke nuisance in cities are at present receiving attention it is of interest to note what means have been employed abroad. One of the most successful foreign installations for preventing the soot and cinder nuisance is in operation at the municipal power plant of Pforzheim, Badenia, Germany. Some time ago the increasing demand for electric current required enlarging this plant and erecting a new stack which, out of aesthetic consideration for the locality, was carried up only 70 ft. high. This made mechanical draft necessary for three new water-tube boilers, each of which has 2375 sq.ft. of heating surface and 65 sq.ft. of grate surface in chain grates. German bituminous coal is used and the plant has been in successful operation for about five years, the only trouble experienced consisting of a slight fall of condensed steam during times of heavy rainfall. When the boilers are first started the stack discharges a yellow cloud of steam, but the color soon changes to white as the operation of the plant is continued. Pieces of white cloth placed over the outlet of the stack and kept there for a considerable time during the ordinary running of the plant, show only a slightly grayish color without having gathered any particles of soot or cinder.

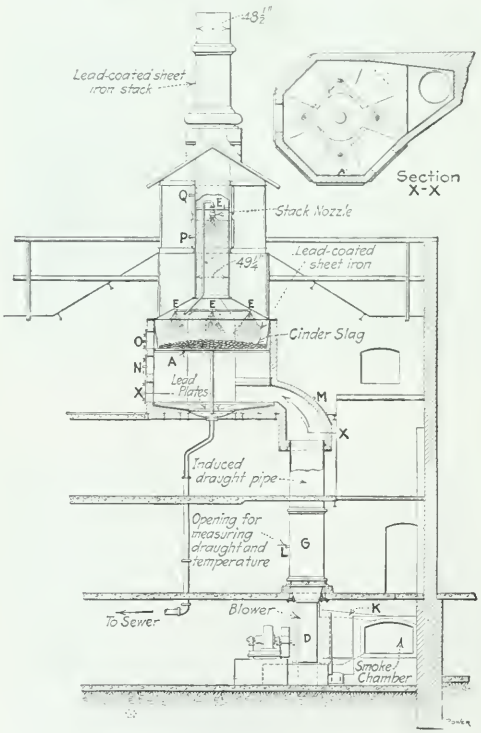


Fig. 1. Sectional Elevation, German Soot and Cinder Arrester

Fig. 2 is a plan showing the general arrangement of the boiler additions referred to and their draft connections, and Fig. 1 is a sectional elevation showing the induced-draft blowers, stack and cinder catcher. Referring to Fig. 2, B_1, B_2 and B_3, are the boilers with smoke connections C_1, C_2, C_3, which discharge into the main smoke chamber F.

The exhaust blower D receives the smoke from the boilers by a short breaching connected with the smoke chamber and forces it into the pipe G, Figs. 1 and 2, from which it passes into the main receiving chamber of the cinder catcher, Fig. 1, which has a cross-sectional area of about twelve times that of the stack. This receiving chamber is of brick, lined on the sides with interchangeable lead-coated sheet-iron plates, while the bottom is covered with lead-coated plates which slope to an opening in the center which is connected to the sewer. Near the top of the chamber is a lead-coated grating A for supporting a bed of broken cinder slag, and above the slag bed is a cluster of nozzles EEE for spraying water as the smoke filters through the bed of slag. A similar cluster of nozzles is provided a little higher up in the stack at E_1. The slag consists of boiler clinker gathered from the ashes made at the plant, the clinker being broken up to about the size of nut coal and spread over the grating, forming a filter bed 12 to 16 in. thick. The water pressure is made just sufficient to raise the water to the height of the spray nozzles with sufficient pressure at the nozzles to properly atomize the sprays.

When the gases from the boiler furnaces enter the receiving chamber, their velocity is reduced, owing to the enlargement of cross-sectional area, and they part with most of their contained solid matter. Then they filter

through the slag filter bed above and any remaining solid matter held in suspension is washed out and the gases are also largely deodorized. The stack and roof of the receiving chamber, and all iron work exposed to the corrosive action of the gases are either protected by a covering of sheet lead or constructed of lead-coated iron.

The above table is compiled from a report of tests

DATA OF TESTS OF A GERMAN SOOT AND CINDER ARRESTER

Boiler in Operation	Measurement Points K	L	M	N	O	P	Q	R	S	Blower R.p.m.	Blower Hp.	Spraying Water per Hour	Pounds of Coal Burned per Hour
B_1, B_2	Draft	1/4	...	...	...	1/16	3/32	3/32	...	210	15	Stack spray only	3000
	Pres.	...	...	...	1	...	...	...	...			1000 gal.	
	Temp.	460	435	415	390	372	122	125	...				
B_1, B_2	Draft	1/8	...	...	...	1/16	1/32	...	1/16	193	12	Stack spray only	2800
	Pres.	...	...	...	1/8	...	...	1/16	...			1000 gal.	
	Temp.	485	464	445	398	380	124	130	...				
B_2	Draft	1	...	...	...	1/16	1/16	...	1/16	217	19	Stack spray only	3200
	Pres.	...	...	...	1/4	...	...	1/32	...			1000 gal.	
	Temp.	473	446	425	360	350	122	126	...				
B_3	Draft	1/2	...	...	...	1/32	1/16	0	...	225	20	Stack spray only	3500
	Pres.	...	...	...	1/16	...	...	0	...			1000 gal.	
	Temp.	435	428	392	296	330	120	126	...				
B_3	Draft	11/16	...	...	...	1/32	1/32	1/16	...	177	9	Stack spray only	1760
	Pres.	...	...	...	...	1/16	...	...	...			1000 gal.	
	Temp.	385	376	349	292	261	110	116	...				
B_2, B_3	Draft	1/2	...	...	...	...	0	0	1/16	203	15	Stack and Filter sprays 1800 gal.	2930
	Pres.	...	1/8	...	1/8	1/16	0	0	...				
	Temp.	500	470	454	338	311	125	138	...				

of the installation made by M. Werner, superintendent of the station. The columns headed *K, L, M, N, O, P, Q, R, S* refer to draft, pressure and temperatures taken at points which bear the same letters of reference in the illustrations; draft and pressure are quoted in inches of water and temperatures in degrees Fahrenheit. The speed

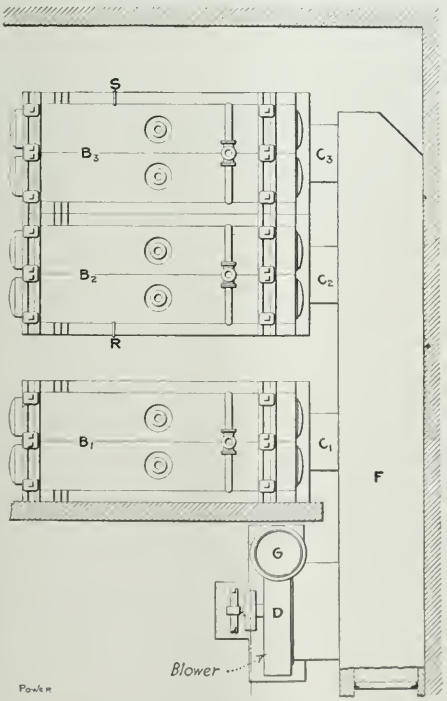


FIG. 2. PLAN OF BOILERS, GERMAN SOOT AND CINDER ARRESTER

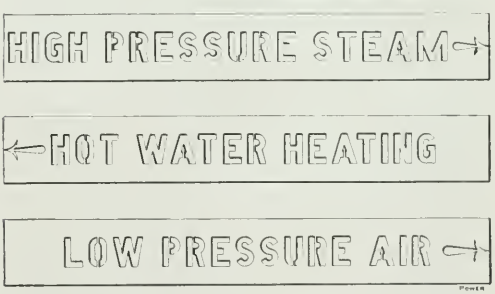
and power required for the blower, amount of spraying water used per hour and pounds of coal burned per hour are quoted in separate columns.

Identifying Pipes

BY L. B. LENT

The writer does not remember seeing in POWER any mention of the admirable practice of stenciling the various lines of piping about a power plant or factory instead of painting them distinctive colors.

Much has been said about painting them and many colors suggested. To me, the principal objection to this system is that one must carry around a color guide or chart in order to identify pipe lines unless one's memory is better than mine. A simpler and better way is to letter each pipe at frequent intervals and also mark the direction of flow alongside the letters. This can be readily done by using stencils. Such marking may be illustrated as follows:



FACSIMILE OF STENCIL FOR IDENTIFYING PIPES

The direction of the arrow shows the direction of flow in each pipe, and such knowledge is often as important as knowing the contents of the pipe. The markings may be 25, 50 or 100 ft. apart, according to the demand of circumstances.

Boiler Blow-Down Recorder

BY PAUL A. BANCEL

The writer recently visited the Phoenixville, Penn., shop of the Heine Safety Boiler Co., and had a conversation regarding blowing down of boilers. Some interesting points which may be of interest to your readers were observed.

The accompanying chart, Fig. 1, is from a Crosby boiler-pressure recorder located in the engine room of the plant, showing about 105 lb. average steam pressure during the working period of the day.

Near the outer circumference of this chart is a series

of dots, one for every hour. These dots show just when the mud drum of a boiler was blown down. Blowing off the mud drum frequently for short periods, instead of periodic blowing for long periods, is less wasteful of heat and prevents sludge and other impurities from clogging

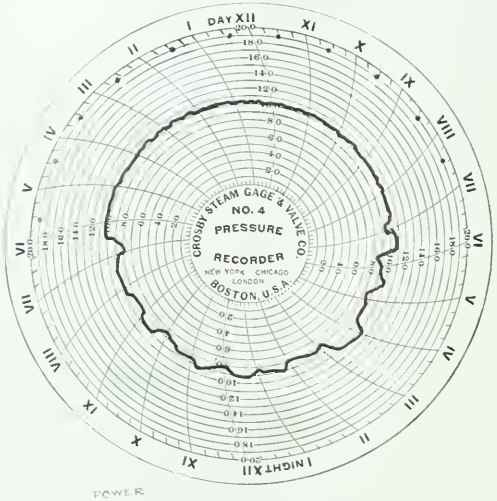


Fig. 1. Dots Show When the Boiler Was Blown Down

up the mud drum and then entering the boiler tubes. Although these impurities are mostly what is called soft scale, if they enter the boiler and combine with the scale deposited in the process of evaporation, they will form a hard scale.

While frequent cleaning of the mud drum is desirable, the tendency in the boiler room is to let the matter go and not blow down regularly. An automatic device for recording the time when a boiler is blown off thus gives the engineer a check on the fireman and insures regular blowing down of the boilers. The home-made apparatus for giving this record, as used in the Phoenixville plant, is shown by Fig. 2.

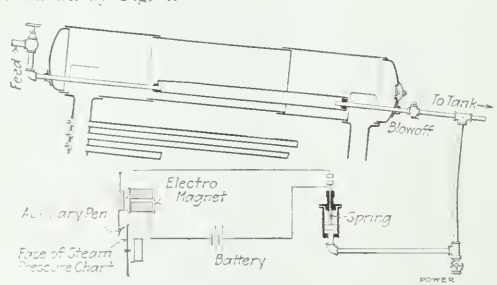


Fig. 2. Connections of Boiler Blow-Down Recorder

Between the blowoff connection and the tank into which it discharges, there is connected a small pipe leading into the engine room where it is connected to a device which closes an electrical contact whenever the blowoff valve is open. This consists of a cylinder in which fits a piston working against a spring. When the blowoff valve is open, the pressure acts against this piston, overcomes the resistance of the spring and closes two electrical contacts.

This causes the current to flow through an electromagnet, situated just above the steam gage on the engine-room gage board. The electromagnet in turn causes an auxiliary pen to press against the steam chart, thus making the dots at the exact time when the blowoff was opened. This device was worked out by engineer James D. Darrach.

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Vertical Terry Turbines Developed and Standardized

A complete line of Terry vertical turbines of from 5 to 600 hp. at speeds of 3600 to 500 r.p.m. has been developed and standardized.

These machines can be dismantled without disturbing the steam connections, and except for the smaller sizes, where all the parts are so light that they can be easily lifted, the casing is divided on the vertical axial plane and the cover or half casing is hinged.

All bearings are supplied with forced lubrication from an oil pump on the main shaft. The thrust is taken by a ball bearing, the balls of which are in oil when starting. A constant circulation of oil through the bearing while running keeps the balls and races cool, clean and free from grit.

These turbines are compact, of light weight and are of the single-stage type, with shaft extension to receive a fan or connect with a centrifugal-pump shafting. These turbines are manufactured by the Terry Steam Turbine Co., Hartford, Conn.

The company has recently put on the market a new type of turbo-alternator, known as the "Terry type C. H. S.," to operate at 3600 r.p.m.

::

Toledo Pipe Cutter

This tool has been designed to cut off pipe in sizes ranging from 2½ in. to 6 in. The cutting is done by four knives, which are automatically fed by star feed. Two of these knives are beveled across the edge, and cut a V-shape section in the pipe. The other two knives are square, and follow in the V-shape cut.

The tool is fastened to the pipe by a three-jawed chuck, each jaw being actuated independently, and containing a set of size marks so the tool can be centered on the pipe quickly. The knives are sent down to the surface of the pipe by turning the "stars" by hand, until each knife in succession comes in contact with the pipe. The tool is driven by a pinion working on a bevel gear, the pinion being operated with a ratchet handle.

The knives are straight pieces of steel, and can be readily reground.

The tool is made in two sections, and splits in two after removing four capscrews. This permits of placing it upon any pipe line before a joint is broken. After placing on a pipe, the two sections are bolted together, and made rigid by dowel pins.

This tool is manufactured by the Toledo Pipe Threading Machine Co., Toledo, Ohio.

Ideal Armored Pump Valve

The material from which this valve is made is a vegetable product treated by a process that is intended to render it nonsusceptible to the effect of steam, oil, ammonia, gasoline, turpentine, etc. It is subjected to pressure, making the material into a solid and practically inseparable form. The seating surface of the valve disk is from one solid piece of this material.

The valve, as a whole, is made of three pieces, an outer casing of copper or brass, secured to the inner casing and valve disk by four screws. The smaller, or inner, casing fits in a recess in the valve proper and does not come in contact with the valve seat.

Should the inner valve face around the valve stud, or the outer face become worn, they may be refaced and made as good as new. The same valve answers for hot- or cold-water service and about the only thing it will not withstand is strong acids. This valve is made by the Lake Erie Boiler Compound Co., 192-198 Chicago St., Buffalo, N. Y.

⁂

Conditions when Estimating the Cost of Power Plants*

By Frederick W. Gay†

Those who make estimates realize the great number and variety of conditions which influence their selection of costs for an estimate on any two separate but similar contracts; in other words, the influence of "local conditions." It is not intended to refer to any particular estimate or specific case, but to analyze the various items which make up the whole in the case of steam-power plants and pumping plants only.

A great many engineers are called on to submit estimates before accurate or sufficient information is at hand as to details of any but the larger and principal pieces of apparatus. Personally, the writer has to make estimates even before any drawings or specifications are available, or even before the preliminary surveys of the site have been made. Many of these estimates cover the expenditure of a great deal of money, and naturally the responsibility is in proportion to the amount of money that is involved.

In some cases estimates can, of course, be checked against cost analyses of similar work already done. Local conditions in new work require that figures from such cost analyses be modified to suit these conditions. How can one check his figures and have any assurance of their accuracy?

Diagrams compiled from data which cover plants from 2000 to 40,000 kw. capacity show that: Engines and foundations constitute from 33.6 to 61 per cent. of the total equipment cost; an average of 50 per cent. Boilers, settings and foundations, from 17.25 to 31.5 per cent., average about 25 per cent. Piping, complete, from 7 to 17 per cent., average about 11 per cent. Condensers complete with foundations and auxiliaries, 10 to 15 per cent., and average 11 per cent. Circulating-water system, 4.5 to 8 per cent., average 6.5 per cent. Thus in these five groups is a minimum of 72.35 per cent. of all apparatus items, leaving the remainder, 27.65 per cent., to be divided among at least 11 groups, including "miscellaneous."

Boilers, foundations and settings can be estimated closely, as can also the condensing apparatus. Engines, foundations, piping and circulating-water systems present greater difficulties, relatively, about in the order named. It is possible to estimate as close as 3 per cent. on boilers installed; on engines, installed, 5 per cent.; on engine foundations, 10 per cent.; on circulating-water systems, 15 per cent.; on piping systems, 20 per cent.; on condensers, auxiliaries and foundations, 3 per cent.

Applying these percentages of error to the minimum percentages of the whole, the total probable error on 72.35 per cent. of the apparatus is as follows:

		Per cent.
Boilers	17.25 × 3	= 0.52 (+ or −)
Engines	33.60 × 6	= 2.01 (including foundations)
Piping	7.00 × 20	= 1.40
Condensers	10.00 × 3	= 0.30
Circ. water syste..	4.50 × 315	= 0.68
Total		4.91

Assume for the moment that the total cost can be estimated as closely as 15 per cent., which percentage ordinarily includes 5 per cent. for contingencies and errors. If by concentrating attention on the five principal groups one can come as close as 5 per cent. on the larger items, and this is possible, then there is a leeway of about 43.5 per cent. on the remaining items. Certainly, in almost every case one can come within 20 per cent. on these items, and if so, the total estimate is within 8.5 per cent., as against the 15 per cent. assumed.

Herein have been used the minimum percentages for the principal items. In some cases this is as high as 85 per cent. If this is analyzed in the same manner as for the 72.35 per cent. the total estimate may be within 6.5 per cent.

Buildings for this apparatus vary from 6 to 16 per cent. of equipment costs, an average, say, of 10 per cent. Using unit prices, on a square- and cubic-foot basis, as well as for horsepower and kilowatt bases, checking each against the other, will probably keep the error within 10 to 15 per cent., a percentage of 1 or 1.5 on the total.

⁂

Detroit "300" Grease Lubricator

This lubricator is designed to feed grease, nonfluid oils, and similar lubricants evenly, economically and efficiently. The heating chamber of the lubricator is of sufficient size to reduce the lubricant in the reservoir to a liquid condition when steam is turned on.

Cold drafts, outside exposure or temperature variations do not affect the operation of the lubricator and the oil or grease in the lubricator is maintained in a fluid condition at all times with an even rate of feed and fine regulation.

The lubricator can be installed either with both connections between the boiler and the throttle or else with the condensing tube above the throttle and the delivery or support arm below the throttle. To permit either installation, there is attached to each lubricator a choke to be screwed into the support arm in case the connections are made on both sides of the throttle. If both connections are above the throttle, the choke is not required.

This lubricator is made by the Detroit Lubricator Co., Detroit, Mich.

*Abstract of a paper published in the "Journal" of the Worcester Polytechnic Institute.

†Chief mechanical engineer, J. G. White & Co.

ELECTRICAL DEPARTMENT

Meter Test Boards

By G. C. Cassard

In designing a switchboard for meter testing, two features must be given consideration: One is simplicity and cheapness in first cost, and the other is convenience, with the resulting cheapness in operation. Of these two factors, the latter is by far the more important, especially as the testing demand increases. However, where the meters are few and of small capacity, a simple board may be found advisable. This type will be considered first.

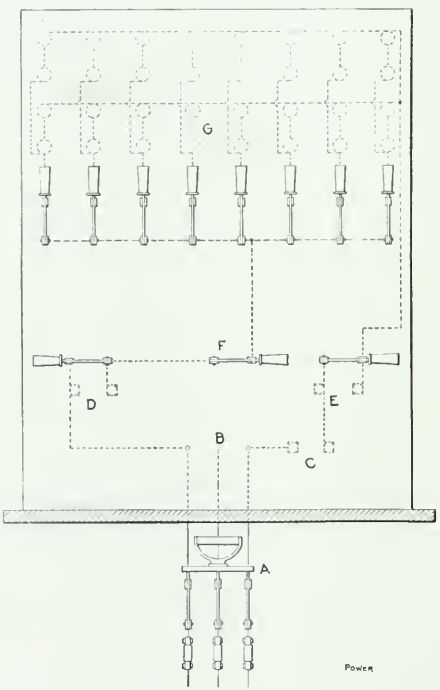


Fig. 1

The switchboard proper (Fig. 1) is supported about 2½ ft. above the floor by an iron frame, extending forward at this point to support a wooden work table. The meter to be tested is hung on a small portable frame set up on this table.

The service is in this case single-phase, three-wire and comes up from below to a main line switch *A*, mounted under the table, and which serves simply to cut out the board when not in use. The service continues to *B*, where three binding posts are provided for taps from the meter potential circuits. From this point on, the neutral is discontinued, the load being designed to operate on 220 volts. At *C* is a pair of binding posts for connecting in the standard instrument: *D* and *E* are two more pairs of posts provided with short-circuiting switches; *F* is a switch for opening and closing the circuit, and *G* is a bank of lamps.

In testing two-wire meters, either *D* or *E* may be used for the current connection, but the one not used must be short-circuited by its switch as shown.

Three-wire meters are connected at both *D* and *E*, the two field coils being fed by the opposite sides of the system. This is a very desirable feature and one that has been given little attention in switchboard design. It

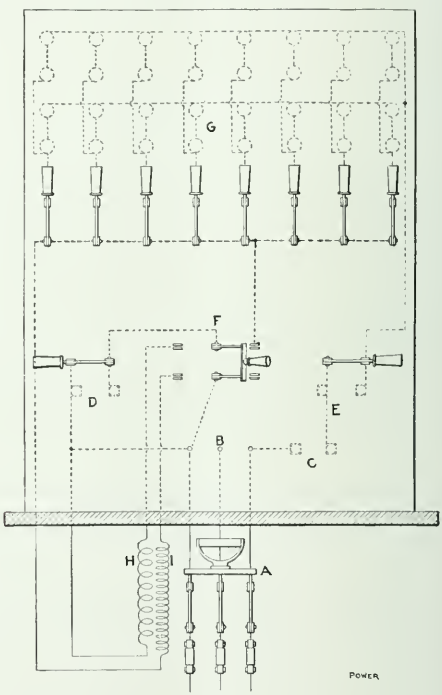


Fig. 2

has been the usual practice, in testing these meters, to connect the two fields directly in series by using a short wire jumper. The fields are thus brought to the same polarity, the disadvantage of which arrangement is apparent. The potential circuit is normally tapped from the same terminal blocks as the fields, and it becomes necessary to disconnect one of these fine pressure wires and attach it to a temporary tap taken from the other side of the system. With the arrangement shown in Fig. 1, this work is unnecessary, the load being in circuit between the fields, just as is the case when the meter is in service.

Provision is also made in this, as well as in the other

three sketches, for bringing the potential tap for the armature circuit to the left post of each pair of binding posts, as the service is supposed to be on the left in all these cases and the armature tap must be on the service side. In most test rooms a current range of at least 200 amp. is occasionally required. A large capacity may be provided by artificially loading the test circuits without actually making a demand on the outside service in watts indicated.

In Fig. 2, this provision is made for increasing the load by means of a step-down transformer *III* having a ratio of 10 to 1. With the switch *F* thrown to the right, the arrangement is the same as that in Fig. 1 with no transformer in circuit, with the load between the two pairs of posts *D* and *E*. When the switch is thrown to the left, however, this latter advantage is lost—the meter can be connected only at *D*. But the secondary, *II*, of the transformer is now in local circuit with the meter, while the primary *I* is fed from the line through *C* and *E* and the lamp bank. As the load on the bank is increased, its resistance is reduced, thus throwing a greater difference of potential across *I* and consequently across *II*. One side of the armature potential is given by the tie between the primary and secondary shown just above the transformer, and the other tap must be taken off independently at *B*.

It must be remembered that, in testing meters by the use of a transformer, the nameplate ratio is not to be considered constant. The standard instrument is on the primary and the meter under test on the secondary, and their exact ratio should first be determined under various loads and the results plotted, or a table of constants made up.

Figs. 3 and 4 are the same, with the four-blade switch *F* in different positions to make it simpler to trace the circuits. Here is an advantage that was lacking in Fig. 2—the meter fields are on either side of the system, and each field is provided with armature pressure, whether it is directly on the service (Fig. 3), or on one of the transformer secondaries (Fig. 4). The double secondary is necessary here, of course, because the two halves must be at a difference of potential of 220 volts.

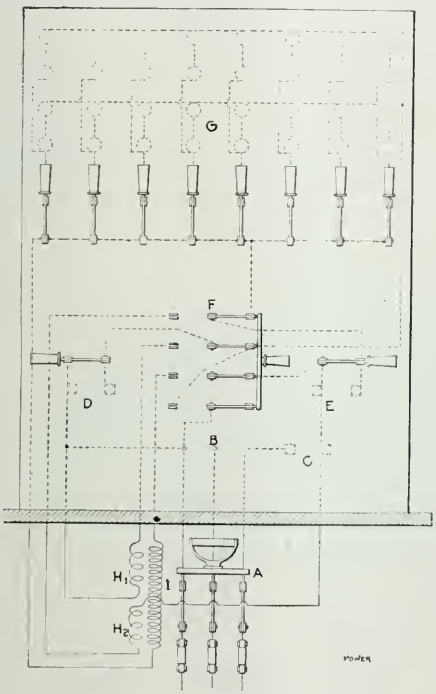


Fig. 3

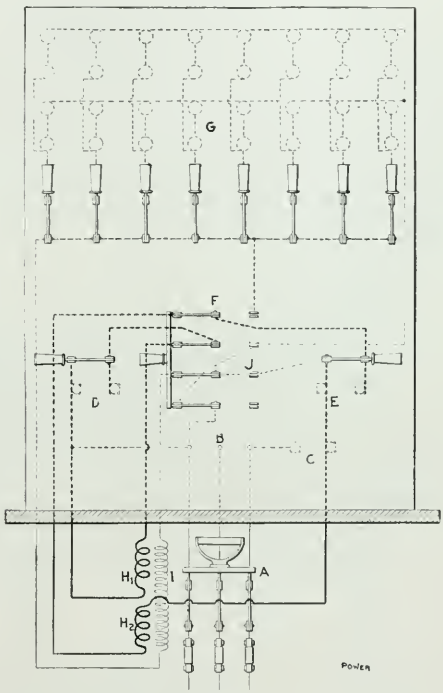


Fig. 4

These two secondary circuits are shown in Fig. 4 in heavy lines and are so arranged with relation to the primary and to each other, that the meter fields will not oppose each other.

That part of the right-hand circuit between *C* and *E* is common to both primary and secondary, and the alterations are momentarily in the same direction.

In the third pole *J* of the four-pole switch, a short jumper ties the clip and base of the blade permanently together on the right side only, but the blade is free to swing with the others.

No "phase splitting" arrangement is shown as it is not a necessity in most test rooms. It may be very simply provided by running in additional pressure wires from taps on the service transformers, thus displacing the phase angle of the voltage rather than that of the current. The primary service is, therefore, brought up to the transformers two or three phase as the case may be, while the secondary service (shown in the drawings) is single phase, as stated.

GAS POWER DEPARTMENT

First American-Built Marine Diesel Engines

The first and only marine Diesel engines to be built in this country are being constructed by the New London Ship & Engine Co., of Groton, Conn. For several years this firm had built gasoline engines for the submarines of the United States Navy, but took up the construction of Diesel engines about two years ago, when the Government specified this type of motor for the submarines then authorized.

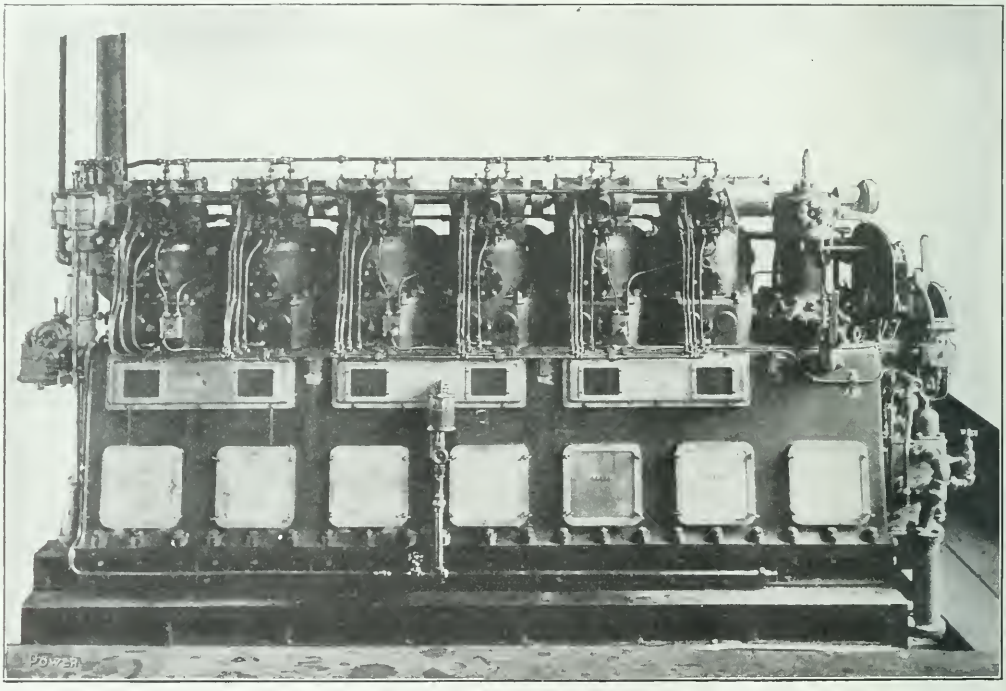


FIG. 1. SUBMARINE TYPE OF ENGINE

The engines are of the Nürnberg two-stroke-cycle type, with slight modifications to meet local conditions. As built for the submarines, they are of the light-weight, high-speed type, 450 hp., six-cylinder, 11x12½ in., and run at 450 r.p.m. Fig. 1 shows one of these engines on the erecting floor.

Taking up this type somewhat in detail, attention is called to Fig. 2, which represents a section through one of the cylinders. The scavenger piston is integral with the working piston, the effective area of the former being about 1.5 times that of the latter. Since they have a common stroke the volume of free scavenging air is about 1.5 times the displacement of the working piston.

In the position shown the piston is on the downward or power stroke, the fuel supply having been cut off and expansion of the gases taking place. At the same time air is being drawn into the scavenger cylinder through the suction valve. When the top of the working piston reaches the upper edge of the exhaust port, the gases begin to escape into the exhaust pipe. Shortly before the lower dead center is reached the scavenger valve is opened by the cam and scavenging air enters the cylinder from the receiver, where it has been stored during the previous stroke. This not only clears the cylinder of burnt gases, but also furnishes fresh air for the compression stroke. The scavenger valve remains open until the exhaust port is covered on the upward stroke.

Considering now the upward stroke, it is obvious that compression begins in the working cylinder as soon as the exhaust port is covered. At the same time, however, in the scavenger cylinder, the suction valve (which opens inward) automatically closes and the discharge valve (which opens outward) opens. Hence, the charge of scavenging air is forced through the discharge valve and

into the scavenger receiver, where it is held under pressure until the scavenger valve opens on the next stroke.

Compression is carried in the working cylinder to 500 lb., and fuel is injected through the spray valve a few degrees before the upper dead center, and is continued for about one-tenth the power stroke. A two-stage compresor driven off the main shaft (shown at the right, Fig. 1) supplies air at about 1000 lb. for fuel injection.

Starting and Reversing

Starting and reversing are effected by compressed air, normally at 800 to 1000 lb., although the engine will start when the pressure in the starting flask drops as low as 225 lb. The starting valve is in the head of the

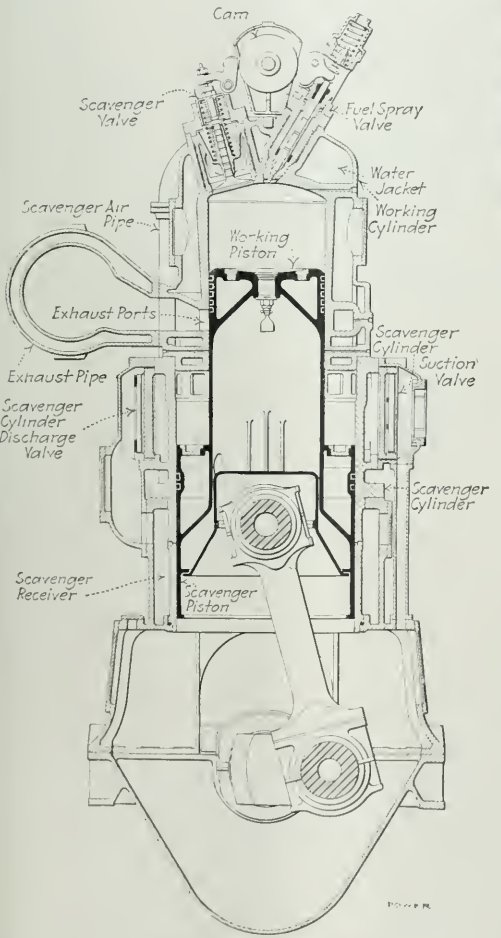


Fig. 2. Section through Cylinder

cylinder, just back of the scavenging valve, Fig. 2. A single movement of the control lever or wheel performs the operation of starting, stopping, reversing and changing speed.

The air starting and reversing system is represented diagramatically in Fig. 3. Air is supplied from the starting flask to the balanced relay valve, flowing through the pipe A to the ahead and the backing-control valves also through the restricted pasage X and the pipe B to the trip valves.

Assuming that the engine is to be started ahead, the control wheel is turned to the right and through a worm

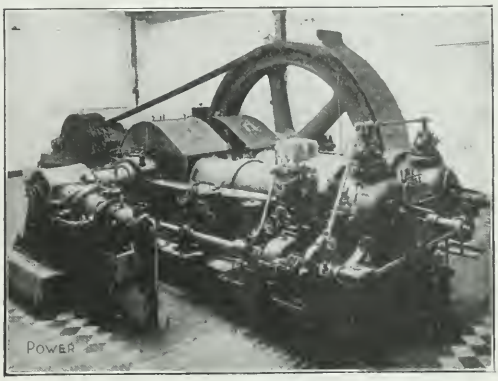


Fig. 3. Stationary Horizontal Type

operates the arm M. This first presses down the plunger P_1 of the trip valve and allows air to escape through the vent. The sudden release of air and the restricted passage X produces an unbalanced presure in the relief valve and causes this to open against the spring, admitting air at high pressure through the pipe D to the starting valves in the cylinder heads. These valves, however, are balanced and for the present remain closed under pressure.

Further movement of the arm M presses down the plunger P of the ahead control valve. This admits air through the pipe E to the distributing valves (one ahead and one reverse for each cylinder), the plungers of which are in contact with the respective cams on the camshaft. This provides a method of selection whereby only that distributing valve, corresponding to the cylinder which has its piston at the proper part of the cycle for starting, will open and admit air to the starting valve. This produces an unbalanced pressure in the starting valve, opens it and admits the bulk of the air from the pipe D, and the piston is forced down. The other distributing valves are opened in turn, admitting air to the other cylinders.

When it is desired to start the engine in the reverse direction, the wheel or control lever is thrown to the left and through the link N operates the astern trip and control valves, the operation being similar to that described for ahead, except that the astern cams and distributing valves are now brought into use.

When the engine is running ahead and it is to be reversed the control lever in being brought back to the central position shuts off the fuel supply; further movement to the left reverses the engine by admitting compressed air as stated and then the fuel is automatically turned on. A brake valve shown at the extreme right automatically relieves the pressure in all the working cylinders before the engine can be started ahead or reversed. A forced-feed system of lubrication is employed.

The light-weight engines of this class designed for naval service, weigh from 50 to 60 lb. per horsepower,

including all auxiliaries, and their fuel consumption is about 0.5 lb. per b.hp.-hr.

For merchant service these engines are made in a heavy slow-speed type, the weight in this case being about 97 lb. per hp. and the speed ranging from 165 to 375 r.p.m., according to the size. The fuel consumption of these heavy slow-speed engines is slightly less than that of the light high-speed type.

Twenty-two of the lighter type of engines are either under construction or have been delivered to the United States Government, and four are nearly completed for the Chilean government. Besides this, one has been installed in a barge for the Standard Oil Co. and another in the yacht "Idalia."

The New London Ship & Engine Co. expect shortly to extend their field to that of the stationary Diesel engine, the type to be put out being shown in Fig. 4.

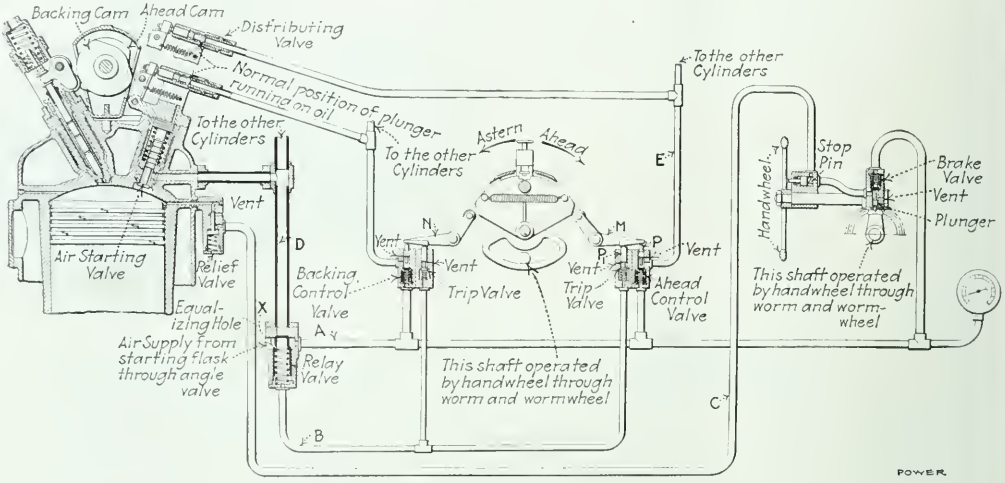


FIG. 4. STARTING AND REVERSING SYSTEM

Gas-Engine Silencers

The most common method of silencing the exhaust of a gas engine appears to be to turn the exhaust into a box whence another pipe is carried to a pit in the ground. This is often filled with loose stones and a final outlet to the atmosphere must be provided to let out the spent gas which otherwise would accumulate in pressure. All these contrivances produce back pressure on the engine.

Perhaps too few of us record our failures in this and other matters. Too late I found out that the Germans had thought out the same idea that I recently put into practice. Wishing to silence an engine and reduce the back pressure instead of augmenting it, the 2½-in. exhaust was tapered up to 3 in. and turned at a fair radius around a corner. Then it tapered up to 4 in. diameter and entered the end of a cast-iron pipe which tapered again from 4 in. up to 7 in. in its length of 9 ft. For about half the length of this pipe a V-slot was cast in each side. The ideas embodied were that the gas should expand gradually into a pipe seven or eight times the original area, reducing its velocity and also permitting it to escape by the V-slots over a length of nearly 4 ft. before reaching the final outlet.

Instead of silencing the exhaust, the tapered pipe seemed rather to act as a megaphone.

The next attempt was to continue the 4-in. pipe at a smaller diameter inside the cast-iron pipe, perforating the new length with numerous holes of an aggregate area considerably greater than the cross-sectional area of the pipe. This did not appear to have the slightest effect and since it was not desirable to delay matters, the exhaust pipe was carried below the floor and into the conventional box placed in a large brick pit, which was vented through a long 4-in. shallow drain to a ditch.

It has not yet been possible to try a new idea which the foregoing failure suggested. It seemed when watching and observing this that the sound, loud as it was, did not travel well around a corner. This suggests that if the exhaust could be carried to a brick well built, if necessary, above ground the noise of the exhaust would go skyward and would be hardly audible at any distance laterally. Something less resonant than cast iron would probably be better. A cone of brickwork stood vertically in a pyramid of clay might serve.

An old engineer suggests that the exhaust should impinge on the point of a cone supported by a light spiral spring in an enlarged chamber as near as possible to the engine. The work of the gas would, he declares, be expended on moving the cone and the cone would spread the gas round its periphery in a thin annulus.

There is very little noise from the exhaust of a motor car when the cutout is closed. These have an effective system but possibly considerable back pressure is at the same time set up. A favorite motor-car silencer is a box three or four times the diameter of the exhaust pipe and containing several perforated division plates of increasing fineness in series. These cut up currents of gas until it escapes in a continuous mass of fine streams. But this is merely curing by obstruction and is not a direct method such as it may be hoped will be ultimately discovered.

London, Eng. WILLIAM H. BOOTH.

HEATING AND VENTILATION

District Steam Heating with High-Pressure Steam*

By Frederick W. Ballard

When the heating of small or moderate-sized factories is under consideration where the buildings to be heated are within a radius of a few hundred feet from the power house, and where the size of the power plant is under, or at most not much in excess of 1000 kw. capacity, then it is more economical to operate the power plant with simple noncondensing engines and use the exhaust steam for heating purposes. The heating plant should be operated under a vacuum system and the back pressure on the engines maintained at practically that of the atmosphere. In such a plant, a charge for the heating should be made to the departments served, and a corresponding credit given to the power plant of about 12c. per yr. per sq.ft. of radiation. The cost of power in a plant of this kind can then be reduced to about 1.5c. per kw.-hr.

In large central stations, operating large condensing steam turbines, and with modern highly efficient equipment throughout, power can be generated for ½c. per kw.-hr., or even less. In such installations it is not good practice nor is it economical to try to run engines or turbines noncondensing for the purpose of securing exhaust steam for heating purposes, or for any other purpose. Due to the backpressure it is only possible to secure one-half or even less than one-half the power from a noncondensing engine or turbine which could have been secured from the same amount of steam; and this fact must not be lost sight of when considering the advantages of an exhaust-steam low-pressure heating system.

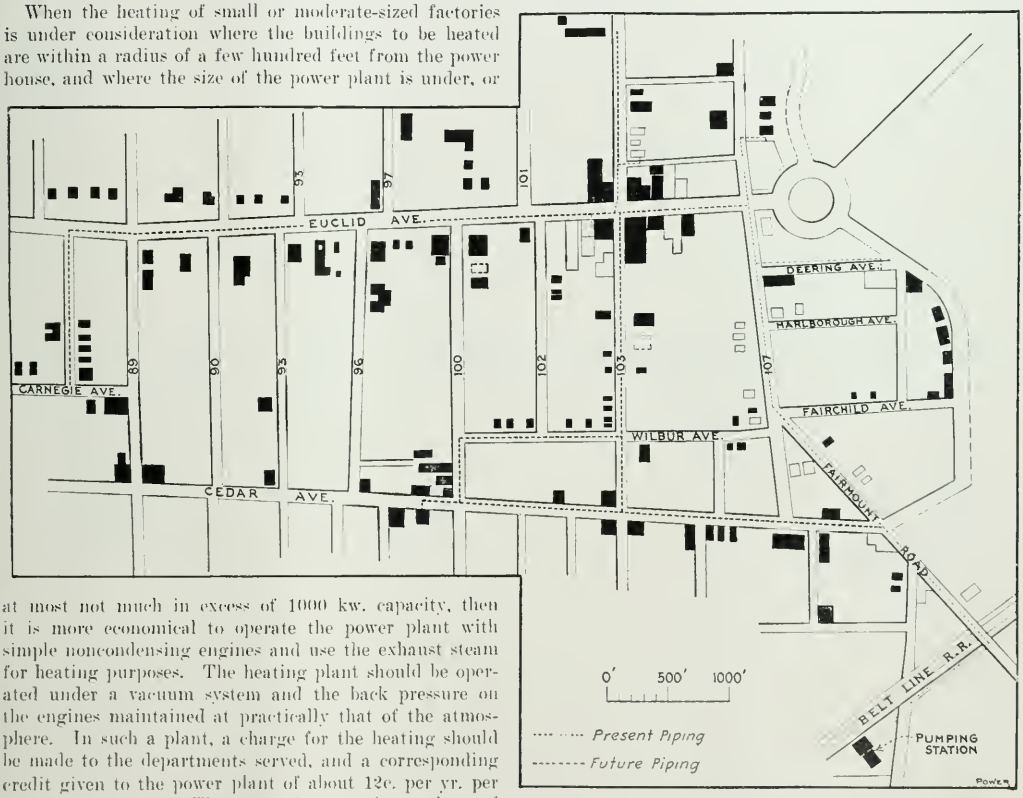


Fig. 1. Map of Complete District

The greatest advantage of a high-pressure system is the much lower investment required by the smaller mains.

TABLE I HIGH-PRESSURE DISTRIBUTION SYSTEM

Section of Main	Approx. Length of Section, Ft	Hp of Steam through Main	Dia. of Main, In.	Velocity of Steam per min.	Drop in Steam Press., Lb. per Sq.In.	Mean Density, Lb Steam per Cu.Ft.	Mean Spec. Volume, Cu Ft per Lb. of Steam
Fairmount P-I to Cedar Ave	2000	2500	10	7875	125 — 107 = 18	0 20	3 12
Cedar Ave. to Euclid Ave.	2000	2000	10	7100	107 — 94 = 13	0 264	3 83
107th to 105th	700	1500	8	9360	94 — 84 = 10	0 236	4 24
105th to 96th	1500	1000	8	7000	84 — 74 = 10	0 214	4 67
96th to end of line	2000	500	6	6800	74 — 57 = 17	0 186	5 36

Another advantage is the lower percentage of heat loss in the mains due to the higher velocities and the smaller amount of surface.

With these ideas in mind we have undertaken in the city of Cleveland the installation of a high-pressure heat-

*Abstract of paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers, Springfield, May 22.

ing system, in which we expect to distribute steam to greater distances and in larger quantities than would be financially possible with low-pressure steam.

In Fig. 1 is indicated the portion of the district already installed and in operation during the latter part of the season just closed, also the district it is expected to serve on the completion of the system at the beginning of next season. Table 1 gives the principal data of the system.

The amount of steam passing through the main in horsepower is based on 30 lb. of steam per hour per horsepower. The initial pressure is 125 lb. per sq.in., and under the conditions shown in Table 1 there will be about 57 lb. pressure left at the end of the main. The drop in pressure for each of the different sections was found by the following formula:

$$P = 0.0001327 \frac{W^2 L\left(1 + \frac{3.6}{d}\right)}{y d^5}$$

where

P = Drop in pressure in pounds per square inch;
W = Weight of steam in pounds per minute;
L = Length of the pipe in feet,
y = Mean density in pounds per cubic foot;
d = Diameter of the pipe in inches.

The mechanical features of a high-pressure system are not difficult. Since higher temperatures are involved, the question of heat insulation becomes more important than in a low-pressure system. The expansion must be carefully taken care of and ample safeguards must be provided in the pressure-reducing valves so that by no possibility can the high pressure find its way to the customer's radiators.

In Fig. 2 are shown the details of a manhole in which an expansion joint is installed. This is a double-slip joint, which is installed every 400 ft. Half way between these expansion joints the pipe is rigidly anchored to heavy concrete blocks and from the anchor to the expansion joint the pipe is carried on rollers in an absolutely straight line. Wherever there is a bend in the line in either a horizontal or vertical direction, the pipe is again anchored securely to take care of any thrust due to the unbalanced pressure.

In Fig. 3 are shown the details of a manhole in which connections are made for steam to the service or low-pressure mains. Sometimes these low-pressure mains serve only one customer and sometimes several who may be grouped closely together. It may be noticed that two reducing valves in series are installed for these connections. The first one is set to regulate the pressure in the service main at 10 lb. The second valve is set to operate at 15 lb., and is intended to come into operation only on failure of the first valve. These second valves are tested regularly by the inspector by holding the first valve open until the pressure in the service main builds up to 15 lb. The second valves being open under normal conditions, the valve seats are always in good condition and the diaphragms do not wear out.

A section of the trench illustrating the method of heat insulation and of draining any water in the soil away from the main, is shown in Fig. 4, and in Fig. 5 the details of the sylphon regulating valve, which is installed in the basement of each individual customer. In addition to the means which this provides the customer for regulating his individual service, it also provides an additional protection against the high pressure finding its way to the radiators. The details of the installation on the customer's premises are shown in Fig. 6. In some instances a regitherm is installed in connection with the sylphon regulating valve, for automatic regulation. This has been found in some cases to reduce the steam consumption by as much as 25 to 30 per cent., as well as relieving the customer of the inconvenience of hand regulation.

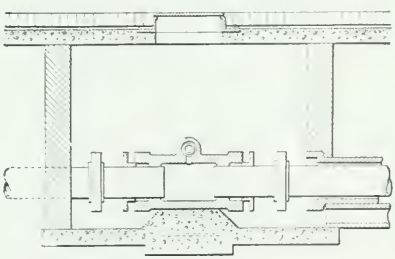


Fig. 2. Details of Manholes, Showing Expansion Joint

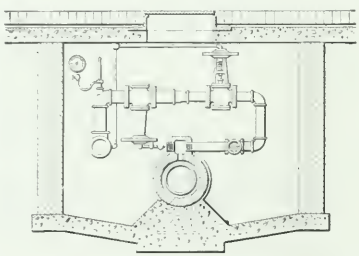


Fig. 3. Connections to Low-Pressure Mains

Fig. 4. Section through Trench

In making a comparison of the size of pipe required for high- and low-pressure systems, one is confronted by the fact that the friction in the pipe varies inversely as the fifth power of the diameter, and that provided a pipe of double the diameter is used the friction is thereby reduced 32 times. The drop in pressure is thus reduced so much by using a slightly larger pipe, that at first sight it might appear as a fallacy to argue that it would be more economical to use high-pressure steam for reducing the investment by reducing the size of pipe. However, when the greatly increased cost of pipe and particu-

TABLE 2. LOW-PRESSURE DISTRIBUTION SYSTEM

Section of Main	Approx. Length of Section, Ft.	Hp. of Steam through Main	Dia. of Main, In.	Velocity of Steam per min.	Drop in Steam Press., Lb. per Sq.In.	Mean Density, Lb. Steam per Cu.Ft.	Mean Spec. Volume, Cu Ft. per Lb. of Steam
Fairmount Rd. to Cedar Ave.	2000	2500	24	5600	15 — 13 = 2	0.074	14.03
Cedar Ave. to Euclid Ave.	2000	2000	22	5770	13 — 11 = 2	0.069	15.00
107th to 105th.	700	1500	18	6700	11 — 10 = 1	0.064	15.79
105th to 96th	1500	1000	18	4730	10 — 8 = 2	0.062	16.76
96th to end of line	2000	500	14	4500	8 — 5 = 3	0.057	19.31

larly the increased cost of valves and fittings when the size is doubled is considered the saving in the investment acquires importance.

For the purpose of comparison, assume a pressure of 15 lb. per sq.in. at the Fairmount Station, and by allowing 10-lb. drop, there will be 5 lb. left at the end of the line, 8200 ft. away. This would be necessary to give satisfactory and reliable service.

For computing the diameter of pipe necessary for each of the sections considered above the following formula was used:

$$d = 0.2 \sqrt{\frac{W^2 L}{Py}}$$

This formula gives the sizes of pipe for the various sections of the distributing mains, as shown in Table 2.

It is interesting to notice that although the pipe sizes are about 2½ times those for the high-pressure mains, the velocity in the low-pressure mains is nearly as great. This is due to the difference in the density of the steam at the different pressures. The costs of installation for both the high- and low-pressure mains are given in Table 3.

The total cost of the mains for the low-pressure distribution system are shown to be about 2½ times the cost of those for the high-pressure distribution system, and means an extra investment of something over $100,000. A conservative allowance for the fixed charges on this extra investment would be 10 per cent., including interest, depreciation, taxes, etc. This means an annual charge of $10,000 against the low-pressure system, over and above the fixed charges against the high-pressure system.

Of course, the reason for the use of low-pressure steam in heating systems is that the steam is first used for the generation of power and the exhaust steam is then used for heating purposes. However, when it is desired to transmit steam to considerable distances, it becomes necessary to carry at least 15 lb. back pressure on the engines. This reduces their efficiency greatly and adds to the importance of the question as to whether it might not be more economical to operate the power station condensing with maximum efficiency and use live steam for the heating requirements. It is seldom, if ever, the case that the heating requirements coincide with the power requirements, and the problem of regulating the load between condensing and noncondensing units, so that the amount of exhaust steam would be just right is difficult. If this is not done then there is likely to be a loss due to exhaust steam going to waste, or, on the other hand, having to supplement with live steam under low-pressure conditions. Leaving this factor out of the consideration, a comparison between the two different methods might be made as follows:

TABLE 3. COST OF MAINS

High Pressure	
4000 ft. of 10-in. pipe	$4,200
2200 ft. of 8-in. pipe	1,761
2000 ft. of 6-in. pipe	1,128
Valves and fittings	15,000
Pipe covering and drain base	11,300
Excavation and back fill	10,560
Pipe fitting (labor)	4,300
Miscellaneous material, concrete, lumber, brick, etc	8,200
Repaving at $1.15 per ft.	9,100
Total cost	$65,549
Low Pressure	
4000 ft. of 22-in. and 24-in. pipe	$15,300
2200 ft. of 18-in. pipe	6,630
2000 ft. of 14-in. pipe	4,600
Valves and fittings	51,000
Pipe covering and drain base	48,500
Excavation and back fill	12,900
Pipe fitting (labor)	6,000
Miscellaneous material, concrete, lumber, brick, etc	12,400
Repaving at $1.25 per ft.	10,000
Total cost	$167,303

Suppose a boiler installation of 2500-hp. boiler capacity such as is being installed at the Fairmount Station. This would be capable of giving 5000-kw. capacity at the switchboard with suitable condensing equipment and a rate of 15 lb. of steam per kw.-hr. This would include the operation of auxiliaries. With noncondensing engines or turbines a fair rate would be 40 lb. of steam per kw.-hr. It would then be possible to generate 1800 kw. with the 2500 boiler horsepower of steam and have about 80 per cent. of the heat left in the steam for heating purposes, but it would be necessary to use low-pressure steam with the necessarily larger mains. This would necessitate the losses due to the larger investment and the increased heat losses due to the greater amount of surface. Only 36 per cent. as much power would be obtained with a consumption of 20 per cent. of the boiler capacity, leaving 80 per cent. of the boiler capacity for the heating, with the same consumption of coal and the same amount of steam produced in each case.

With an expenditure of 20 per cent of the heat value of the steam 1800 kw. of power has been secured. There is 2000 hp. of steam left to sell, having used 500 hp. to generate power which would have required 900 hp. of steam to produce, running the electrical generating equipment separately and with highly efficient condensing

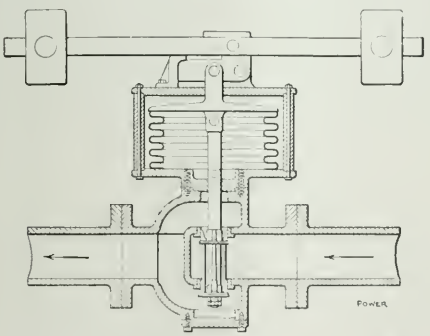


FIG. 5. DETAIL OF SYLPHON REGULATING VALVE

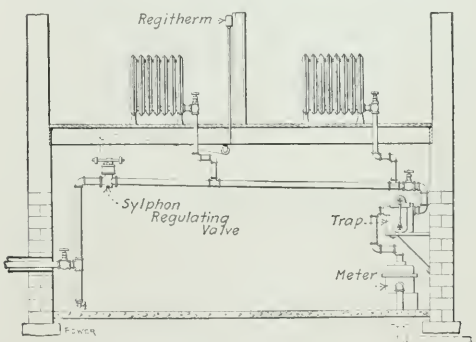


FIG. 6. SERVICE EQUIPMENT

apparatus. This analysis would show that the actual saving which has been accomplished is represented by the cost of producing 400 hp. of steam.

The 400 hp. of steam thus saved would have such a value as it would cost for its generation in a power station, and might be figured on a basis of 10c. per 1000 lb. of steam. The period of time for which the saving should be allowed would be for the six months of the heating season, and to be conservative assume that the saving goes on throughout the 24 hours of every day, although a 40 per cent. load factor on a central-power station is generally considered good. With these assumptions the saving amounts to $5250 per year, but it was just shown that the fixed charges on the extra investment for the low-pressure mains was $10,000. This one item alone costs nearly double what the saving would be from the use of exhaust steam.

There are other items of importance which militate against the exhaust-steam low-pressure system for district heating. The noncondensing engines or turbines cannot be operated economically during the period of time when the exhaust steam is not required for heating. This makes an extra investment necessary for power-generating machinery, the fixed charges on which are quite considerable. Also the impossibility of having the requirements for heating coincide with the requirements for power from a central station means, to say the least, an extra investment in machinery.

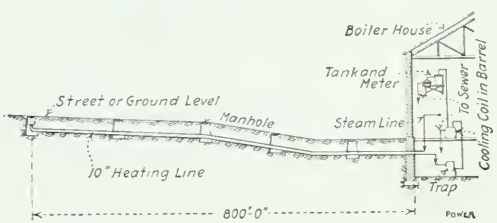


FIG. 7. DIAGRAM OF CONNECTIONS FOR TEST OF PIPE COVERING

There is also an advantage from the use of high-pressure steam, due to the great drop of pressure in the pipe. This does not represent a loss, but gives a tendency to superheat and the customer is supplied with dry steam. In the low-pressure system, there is a large percentage of moisture in the steam when it leaves the station, and to this is added the moisture due to the heat losses along the line. Finally, the losses in the pipe line are much greater in the low-pressure system because of the greater surface of the mains. Just what this amounts to, I have been as yet unable to determine. It certainly is not directly proportional to the square feet of surface, and this to a certain extent would be offset by the greater loss per square foot of surface in the high-pressure main, due to the higher temperature. Such tests as we have been able to make would indicate that, although there is a greater loss from the larger main, it is not in proportion to the square feet of surface, because of the effect of the surrounding earth, which itself acts as a nonconductor.

In Fig. 7 is shown a diagram of the connections for a test on the pipe covering which was made last November. The first 800 ft. of the 10-in. pipe was dead-ended and a pressure of 65 lb. was maintained for about ten days. An efficiency of the pipe covering was found such that the loss amounted to 85 per cent. of the loss which would have been found with bare pipe. There is certainly an opportunity for great improvement in the methods at present obtainable for the protection of underground steam mains.

The question naturally arises as to the limit of pressure which would be justifiable. Table 4 shows the data for 250-lb. pressure through the first two sections of the 10-in. mains of our system.

TABLE 4. DISTRIBUTION SYSTEM UNDER 250-LB. PRESSURE

Section of Main	Approx. Length of Section, Ft.	Hp. of Steam through Main	Dia. of Main, In.	Velocity of Steam per min.	Drop in Steam Press., Lb. per Sq.In.	Mean Density, Lb. Steam per Cu.Ft.	Mean Spec. Volume, Cu.Ft. per Lb. of Steam
Fairmount Rd. to Cedar Ave.	2000	3700	10	6200	250 — 200 = 50	0.57	1.75
Cedar Ave. to Euclid Ave.	2000	3000	10	6000	200 — 160 = 40	0.47	2.14

The drop in pressure in the two sections is shown to be about 2½ times that with the 125-lb. system and with only about 50 per cent. increase in the quantity of steam flowing through the mains. This is because the friction varies directly as the square of the weight of steam through the main. The density does not change so rapidly at this high pressure as the pressure increases. This, taking into consideration the difficulties connected with the generation and handling of high pressures, would seem to set the practical as well as the economical limit at from 200 to 250 lb. pressure for a high-pressure district heating system.

Downward Ventilation in a Rockford School

An abstract of Clinton E. Beery's paper on the above subject before the American Society of Heating and Ventilating Engineers was printed in POWER, Mar. 4, 1913, page 301. In the course of the discussion of his paper, the author added the following information in reply to questions asked regarding the unique system:

The humidifier used in this installation was a simple iron water pan, containing a submerged pipe with a series of petcocks along it. We used low-pressure steam to heat the water, the steam valve being under thermostatic control. This arrangement permitted the passing air to take up a certain amount of saturated steam with it.

A ceiling outlet is not necessary; in fact would never be open during the time that the room was occupied for school purposes. If it were necessary to fumigate a school room, with, say, formaldehyde, the smoke would spread to all parts of the room and if outlets were open at the top and bottom and the fan started, the odors would be quickly dispelled.

There is a decided advantage in placing the heating coils on the ceiling, which is that it reduces the temperatures at the ceiling. The ceiling coils are not intended to be used for heating the room, but for preventing too high temperatures up where they are unnecessary. With outside temperatures ranging around 45 to 50 deg. F., ceiling radiation need not be used as it is not necessary to prevent high final temperatures in the ventilating air. When the temperature gets down to 30 deg. and lower, the radiation on the ceiling is a decided advantage and the benefit is correspondingly increased as the outside temperature continues to go lower or remain low.

Regarding the by-passing of the incoming air to the vent flues, we took a low-pressure steam line and admitted steam to the room until it was completely filled. When that steam blanket got to a low level there was no more reason why it should not go over to the vent flues at the four corners than that the air should do so. But one could not find any place in the room where the density was not uniform. There was absolutely no lateral movement except down considerably below the desk tops.

EDITORIALS

The Price of Gasoline and Oil

In an article entitled the "Gas and Kerosene Situation," the *Scientific American* says:

United States Government reports show that the advancing price of gasoline is due solely to inevasible laws of supply and demand. No corporation or combination of corporations is responsible for the fact that demand has overtaken production, and that further increases in prices are now impending.

The United States government reports do not show that it costs 60 per cent. more to produce gasoline this year than it did last, nor any more for that matter.

There is no question but that the producers made a generous profit at last year's prices. Only when a long-suffering people shall decree that prices upon such commodities shall be based upon the cost of production, and shall be only such as to pay a fair profit upon the investment actually employed in that production instead of what the traffic will bear, will the user of a gasoline or oil engine know how badly he is to be held up for his next fuel contract, and the engineer and power user be able to compare the economical advantage of liquid and solid fuel, internal-combustion and steam engines upon a stable and intelligent basis.

⁂

Engineers' Salaries

The inadequacy of the salary—should we rather say wages?—of the operating engineer is a subject of frequent comment, especially among members of the craft. The recognition of the engineer, socially and financially, has not kept pace with his growing attainments and responsibilities. It is only comparatively recently that there have been many plants which justified the employment of a man of wide attainment. Today the complexity of the power plant has become such that no mere laborer can keep it going, and the saving possible in a plant of even moderate size warrants the employment of a man who knows power-plant engineering.

The money paid to many of these men is woefully insufficient for the type. Heads of departments demanding much less executive ability, training, effort and responsibility command higher salaries in many lines. For much of this the engineers have nobody but themselves to blame.

In New York there has recently been completed the largest office building in the world. It has its own steam plant with all that that means in heating, ventilating, pumping, lighting, refrigerating, etc. The engineer of such a building must be a good deal of a man, and it should mean much to a man to be engineer of such a building.

Evidently many engineers thought so, for there was no lack of applications. One who offered to take it for $1500 says he was offered $1800, which munificent offer was also received and refused by others.

It is commonly reported that the present incumbent took it at that price. The agent of the building refuses to tell the exact amount but says it is "about $2400."

The man who takes a position like that of engineer of the Woolworth Building for $1800 a year does not only himself but every member of the craft an injustice. If he is big enough for the job he is worth more money, and ought to stand out for it. If he is not worth more than $1800 a year, he is not big enough for the place.

This job at this price will help to hold salaries in New York down to the present low level. Why should the employer who knows that such an immense building pays but $150 per month expect to pay his engineer on a comparatively insignificant plant more, or even as much; especially if he can get somebody—and he can— to take it for less?

Who was it who said that the world is prone to take a man at his own valuation of himself?

⁂

Studying Wiring Diagrams

In these days of conduit wiring, installations properly planned give little trouble, and their permanent character from the wiring standpoint gives the average engineer little to do in comparison with the demands upon early electric-plant operators in making up connections, soldering cables and arranging auxiliary conductors. At the same time it is important for the progressive engineer to understand the wiring in every plant for whose electrical apparatus he is responsible, and spare time cannot be better expended than in the study of local circuits and the puzzling out of their details.

The easy-going man gets along reasonably well, it is true, by always falling back upon the manufacturers for the details of connections to and from his more complex electrical apparatus, but he who aspires to the real mastery of his installation will not rest content until he has conquered these details once and for all time, and put them down in black and white for convenient reference.

In a modern plant, where the wiring is laid out far in advance of its actual installation, it is often a problem of great complication to make a complete wiring diagram on the premises after operation has begun. It is sometimes almost impossible to follow the course of electric circuits without the aid of the original plans, and there should be rare occasions for this. The engineer is entitled to full sets of plant drawings from the designers and manufacturers, and he is entirely within his rights in asking for copies of wiring diagrams of the original layout as an aid to proper operation and intelligent anticipation of future changes in the equipment and its arrangement.

But if he cannot obtain these, and in some cases such drawings are never completely assembled, he can set himself the fascinating and helpful task of preparing loose-leaf or sketch diagrams of specific systems of electrical service within the station. It is a mistake to suppose that all home-made wiring diagrams should show every wire and finally be massed together in one impressive but

bewildering effort to put the entire installation on a single twenty-four by thirty-six-inch tracing. In these days it is more important to possess accurate sectionalized information about the individual electrical systems in the plant, and the combination of such diagrams is largely a matter of personal taste, depending upon the size of the installation and the amount of time at hand for the work.

Economy is served by the use of single-line diagrams in place of the elaborate two- and three-phase line drawings formerly looked upon as necessary, and the detailed interior connections of apparatus units may well be omitted in system sketches in many cases. The manufacturers of voltage regulators, exciters, battery-charging equipment, motors and other more or less complex machinery almost invariably will supply detailed interior circuit drawings without cost to the engineer, and these can be transferred to a loose-leaf wiring book as occasion offers.

One set of drawings, for example, may show the diagrammatic arrangement of busbars, generator leads, oil switches and feeders, leaving the main switchboard or bus compartments; another set may show the connections in skeleton form of the local station-lighting circuits, and another set may give the outlined relations of the auxiliary power-motor leads and controlling switches.

Throughout all work of this kind the engineer should keep its object closely in mind, and that object is primarily the clearing up of every mysterious detail in the connections for which he is responsible. No better mental discipline exists than the study and composition of wiring diagrams. The work demands imagination, accuracy, perseverance and insight, and may well occupy the attention of ambitious engineers keenly alive to the benefits of looking deeply into phases of power-plant operation beyond the comprehension of the layman. Such work helps to fit a man for grappling with bigger problems and makes him a more valuable employee.

Mastering Details

The prominence given to executive responsibilities tends to obscure the faithful performance of detailed work. The daily tasks of the engineer are filled with details of equipment and operation which, individually, may be overlooked, but, collectively, often make or mar the reputations of the high-salaried officials under whose general jurisdiction they are performed.

It is absolutely necessary then to master details in order to attain any lasting individual or organized success. Cultivating enthusiasm for the drudgery of one's position will lead the man with a reasonable aptitude for his occupation and plenty of staying power to the plans of the expert and away from the level of mediocrity. And it may be put down at the outset that the reward of really mastering one's daily work comes with the knowledge that one is equal to the emergency, wholly apart from the question of pecuniary benefits.

With the busy engineer, as with everyone, days come in which his tasks seem anything but worth while; in which the familiar duties look shopworn and burdened with routine. At such times "every ship is attractive except the one in which we sail." This is the time which tests the man of purpose and requires an extra effort on his part to attack the problems which confront him with a determination to make every little detail of his work right, to leave nothing done in a slipshod way, and to dig deep down into the perplexities which beset him.

It may be that a new type of valve has been put into the plant under the pressure of necessity, leaving the engineer practically no time to study its fine points, or that an automatic voltage regulator misbehaves and spoils the chart produced by the curve-drawing meter. Here is the engineer's chance to make life miserable for the concern that manufactured the valve or regulator until it supplies him with drawings or photographs of the interior parts, and descriptive matter in print or verbatim, which he could not obtain under the stress of the installation. It is his duty to study the details at the earliest available hour, and it is only his neglect to do so which may properly be blamed.

Whether it is taking indicator cards, fitting pipe, stopping leaks or packing valves, the engineer's work is so much one of detail that the mastery of these tasks in large degree fits the ambitious man for larger responsibilities. It is the custom in many plants to lay upon the engineer's shoulders the troubles of the entire establishment, so that he sometimes wonders if he is not a cross between a janitor and a plumber. The wise man, however will hesitate a long while before he refuses to perform the duty nearest at hand.

Less than three years ago the vice-president of a large railway company, then a rising executive assistant in the manager's office, made it his personal task to see to it that the president's chauffeur brought the former's car to the door of the hotel at exactly the right moment following the conclusion of every meeting, a duty which any $3 a week office boy could doubtless perform, but which the high-priced man took upon himself in his determined efforts to be of the utmost possible use in every way

No, the details must be done properly if the work as a whole is to stand, and just as each inch of wire in a transmission line a hundred miles long must be continuous and without break for successful service, so must the chain of detailed jobs done one by one in the silent criticism of one's own judgment and loyalty to the best work that he knows, establish a reputation for reliable and skillful performance, which is the reward of the master of those little things so often scorned as mere details, but of such cumulative power in the efficiency of every industrial enterprise.

Available CO_2 Percentages

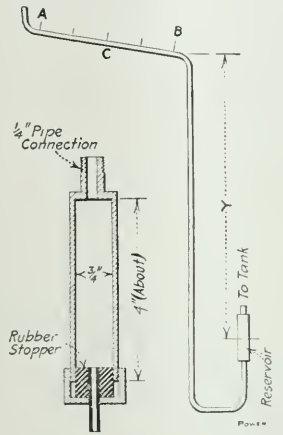
Flue-gas analysis is by no means common among engineers, and its popularity is not enhanced by the innocent symbols and terms met with in the use of the Orsat. Some of those with whom the practice does become popular overlook important factors influencing the maximum CO_2 available when burning fuels of different compositions. Failure to adequately consider and make allowances for these factors has been the cause of injustice to firemen ordered to maintain a standard percentage of CO_2 when burning coals of widely varying qualities.

Mr. Pohlman's letter, recently published on the subject of available percentages of CO_2, and the subsequent discussion on the subject have proved of especial interest and value.

READERS WITH SOMETHING TO SAY

Mercury Liquid-Level Gage

The writer recently had a cylindrical tank about 18 in. in diameter and 3 ft. high which was placed in an inaccessible garret used for the storage of crude oil. The oil was pumped up to the tank from an outside source and then allowed to flow back to a small burner used for house-heating purposes. Some means of telling just how



Details of Mercury Liquid-Level Gage

much oil was in the tank was necessary. The sketch shows the apparatus used to do this.

A glass tube about ⅛ in. inside diameter was bent, as shown, and connected to a steel container or reservoir, the details of which are shown in the enlarged drawing. The apparatus was mounted on a board and placed in a vertical position on the wall in the room where the pump was situated. The upper end of the reservoir was connected to the pipe leading to the tank. The difference in level between the bottom of the tank and the mid point of the reservoir was about 20 ft. The distance *Y* was made of the proper length so that when the glass tube and the reservoir were filled with mercury and the oil was at its lowest level in the tank in the garret the mercury would rise to the point *B*. The part *C* was about 12 in. long and inclined, as shown, so that the mercury would rise to the point *A* when the oil tank was full. Knowing the capacity of the tank it was an easy matter to calibrate the distance *AB* to read in gallons.

Readers of POWER may have occasion to use some such device and for their convenience it may be stated that 0.884 in. of mercury will balance one foot of water. If the tube *C* is made one foot long, then for every foot depth of the tank the inclination of the tube *C* should be ⅞ in.

WILLIAM D. HALSEY.

West Chester, Penn.

Cannot Lubricate Pump

I have a duplex hydraulic pump operating a hydraulic press, the pump is of the slide-valve pattern, and steam to it is controlled by an accumulator. Steam at 110 lb. is delivered to the head end of the steam chest.

A mechanical lubricator was connected to the top of the valve chest and oil fed into the center of the valve chest though the top cover, the lubricator was controlled and operated by a rod which was bolted to the right-hand valve rod. By this arrangement it was found that the right-hand cylinder did not receive any oil while the left-hand cylinder received it all. On suggestion by the manufacturers, the connection was removed from the top of the steam chest and connected into the steam pipe 24 in. from the valve chest. The operating rod was taken off the right-hand valve rod and connected to the left-hand valve rod, still the right-hand cylinder does not receive oil while the left-hand cylinder is well lubricated.

The valves in both cylinders are set properly and there is no obstruction that would prevent proper lubrication. Both plungers are doing their share of work. I would like to hear some comment on this trouble.

J. B. LAKE.

Newark, N. J.

[So long as the operating lever has sufficient throw to give the proper stroke to the oil-pump plungers, it does not matter to which valve stem it is connected.—EDITOR.]

Fitting Crankpins in the Backwoods

Having seen occasional inquiries in POWER in regard to loose crankpins and the methods used to repair them, induces me to give some of my experiences with them.

Soon after going to work in a machine shop I was sent to a big sawmill to fit a new crankpin in a lumber gang, the old one being loose. The new pin, 5 in. in diameter and 14 in. long, was made with the tapered end considerably larger than the finished size, but so it would go about three-quarters of the distance through the crank disk; the taper was as near the right taper as we could get it. On trying it in the hole and testing for fit, we found the hole considerably out of round, and out of square.

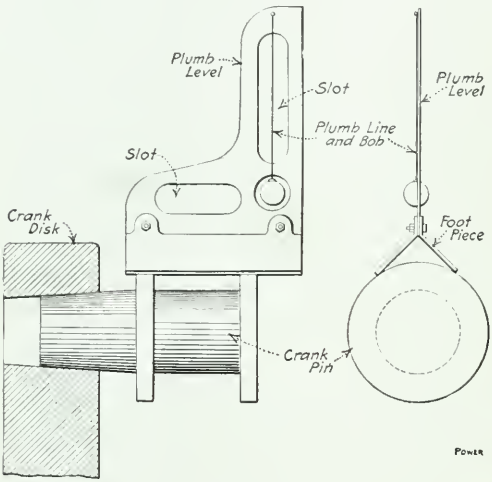
Coating the tapered end of the pin with red lead and oil, the pin was tried in the hole and rotated slightly back and forth. On removing the pin the high spots showed plainly and were dressed off with file and scraper. This was done repeatedly, gradually rounding the hole and at the same time dressing it, so as to bring it square with the crankshaft. We tested for square by using a tool called a plumb level made as illustrated. As the hole approached completion the shaft was rotated and placed on both dead centers and on the two quarters, and the pin tried for square in each position.

If, as the pin was gradually worked into the hole, the taper changed slightly or it was found to be too large, it was taken to the machine shop, which was near-by, and a

cut taken off in the lathe. This was done several times, care being taken to have the pin the proper distance in the hole when the fit was perfect. It was slow work with the frequent trials of the heavy pin and repeated turning of the shaft to get at the high spots. After the hole had been dressed to a near fit, fine emery and oil were used to grind down any slight inequalities in the hole, making a ground fit.

If the pin was still out of square as the hole approached a good fit, we set the crank so the weight of the overhanging end of the pin in grinding tended to work the hole in the proper direction.

In fitting the pin allowance was made for a shrink fit. The pin being finished and ready to be forced in the hole,



Crankpin Level

the crank disk was heated by placing red-hot chunks of iron in the hole and changing them frequently, and by bent pieces of flat iron made red hot and placed on the outside of the disk and changed as they cooled. A heavy ram was also hung in a convenient position. When the disk was as hot as seemed advisable the pin was inserted and two or three blows of the ram were sufficient to drive it home, when the end was riveted over. This was my first job, but since then I have fitted probably twenty-five large pins and have never had a pin come loose.

I have fitted a few engine crankpins, where the old ones were loose, using this same method, and always found the holes out of square. Of course, this plan can only be used in a taper hole or by making a straight hole tapering, as I did, about four years ago, where the crankpin of a 22x48-in. engine came loose.

On removing the old pin it was found that the hole was originally parallel, but being both out of round and out of square, and no boring rig available, it was decided to put the new pin in by the method described. The hole was tapered by hand, using a temporary piece of iron to start the taper, and a lasting job was done. This crank was an arm instead of a disk and was heated to shrink in the pin by putting it on the outer center and placing a portable forge under it at the hole. The taper of these crankpin holes was about ¼ to ⅜ in. per foot.

At the place where so many pins broke, we got a cast-iron sleeve made the size of the pin, cast hollow to make it light, and used it to fit the pin. This saved lots of lifting in not having to use the heavy pin for that purpose. For grinding and rotating the pins we used wood or iron clamps with handles.

In using the plumb level the shaft should be level, or if a little out the plumb should show on the pin the same as when applied to the shaft.

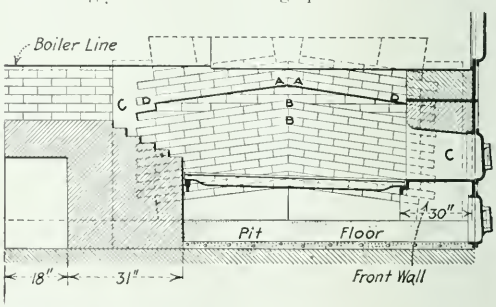
W. E. Stickney.

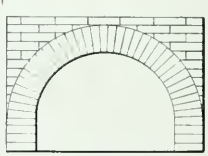
Prince Albert, Sask., Can.

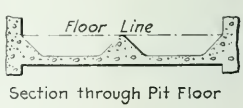
Innovations in Furnace Walls

Has any reader tried laying the firebricks of furnace side walls in any other way than horizontally or perpendicularly? I know of one engineer who claims a marked improvement, and no small saving of time and outlay, by coursing the bricks as shown. He has also included in the design of his furnace other innovations, the most radical of which are depicted in the illustration.

The engineer's claims for his design are: No expensive skilled labor required; the key bricks *A* and *B* are made to order, and the pillars *CC* are so distanced that the bricks snugly fill the intervening space. As there is no







Details of Furnace Design

trimming to do, the least intelligent helpers, when aided by a guide, reaching from pillar to pillar, can lay the bricks satisfactorily; each course of bricks is self-contained, as shown at *DD*. The keys force the bricks snugly together.

Less material is used and the boiler is out of service but a short time during repairs. As the affected area is inclosed no time is lost in supporting the standing wall in making connections thereto, and it takes less time to dry the wall.

As to wear, the engineer showed me his log book, from which the following representative figures were copied:

Before the change:	
391 fire bricks at 3 5c....	$13 68
Fireclay	1 50
Labor, mason, two days at 0 80 per hour	12 80
tender, two days at 0 50 per hour	8 00
Total	$35 98

The walls required repairing on an average of once in eight months.

After the change:	
252 fire bricks at 4c.	$10.08
Fireclay (some used for pointing other work)	0.40
Labor, two helpers, two days at $2 per day	8.00
Total	$18.48

The walls required repairing on an average of once in 13 months. The engineer claimed headers in the wall were not needed, as the bricks were so tightly packed they could not fall inward.

Other peculiarities of the design are the long bridge-wall top, to heat cold air when the furnace doors are open or a hole is burned in the fire; also, the ridged ashpit, shown.

There is one "improvement" the engineer is in doubt about. He is not certain of this innovation, but experiments seem to bear him out. He looks upon the furnace wall as a compound engine. The inner section, between the fire and the air space, corresponds to the high-pressure cylinder; the outer section, to the low-pressure cylinder, and the air space corresponds to the receiver. Now the higher the receiver pressure, the less will be the initial condensation in the high-pressure cylinder. Likewise, the higher the temperature of the air space, the less will be the loss of heat by conduction through the inner wall; for the transfer of heat by conduction varies directly as the temperature difference between the inner and outer surfaces.

It is admitted that more heat travels across the air space by radiation than would flow by conduction were the brickwork solid. From this, he reasons that if he covered one side of the air space with some smooth material, such as glass, the heat would be reflected back to the inner wall and its conduction through the outer wall checked. To cover the wall with glass being impracticable he has used the next best thing—bright tin.

He made tests of his theory by imbedding thermometer receptacles in the walls, and applying the instruments thereto, whose readings proved so complimentary that he had all the air spaces lined, but whether the result is due to the reflection of heat from the tin, to the diminution of air leakage through the setting by the use of the air-proof lining, or to some other cause, his experiments were not carried far enough to determine. However, whatever the cause, an improvement was effected.

R. O. Richards.

Framingham, Mass.

Injector or Pump Most Economical Boiler Feeder?

The assertion is sometimes made that an injector is the most economical boiler feeder, and, on the other hand, some say that a pump and heater is the most economical. I have never seen any figures given to prove either statement. I have made a comparison of the two in a plant where the conditions from day to day are as nearly uniform as can be found in a manufacturing plant.

We have two sets of boilers—twelve running for power and four for heating. Each set has a steam pump and a heater and each boiler has an injector. The steam available for the heaters is the exhaust from two air compressors, and two pumps. The heaters condense all of the exhaust steam, so that no steam comes from the exhaust pipes.

With both pumps and heaters working, and with winter temperatures the feed water entering both systems is from 50 to 75 deg. F. By feeding the four heating boilers with the injector and passing all the exhaust steam through the large heaters, feeding the 12 power boilers with the pump, the feed water in both systems rises to 150 deg. Again, by feeding the four heating boilers with the pump and heater, and the power boilers with the injector, passing the water from the injector through the heater we get a feed-water temperature of 180 deg. in both systems.

We can, therefore, compare the coal consumption under both conditions. I have done this on alternate days for two weeks, and, without exception, on the days when the injectors were used, the coal burned in the power boilers was over a ton less than on the days the pump was used, all other conditions of load, etc., being the same. I might add that the injector we have is a high-grade locomotive type that can be reduced 60 per cent. of its capacity, and it is not stopped from 7 a.m. to 6 p.m.

W. E. Hopkins.

Torrington, Conn.

[It should be noted that the amount of exhaust steam available for the feed-water heater is small in this plant. —Editor.]

Gases in Furnace Explode

An incident which I witnessed recently serves to show the need of caution in furnace operation.

The steam pressure having risen to the point of blowing off, the fireman unhooked the damper chains from the regulator, closing the damper tightly. This was the course usually pursued when the boilers were left for the night. As we were blowing down the boilers the fireman proceeded to blow down the water columns, which were piped so as to discharge into the ashpits. He had just finished when I called him to me some ten feet to one side of the furnace doors to tell him of the probabilities of a furnace explosion with conditions as they then prevailed.

The words were hardly uttered when an explosion occurred. The furnace, ashpit and combustion-chamber doors were blown open, allowing fire, smoke, gas, etc., to be blown into the room. It was well for the fireman that he stepped to one side at the moment he did as he could hardly have escaped being badly burned. The supposition is that the proportions of carbon monoxide and air happened to be just right to make an explosive mixture, and being bottled up by the tightly closed dampers, an explosion occurred. The settings were not wrecked, but, no doubt, the relief afforded by the various doors was all that saved them. It would seem that it is unsafe to pipe up blowoff lines from water columns, etc., to the ashpits. When they are piped in this way the columns should never be blown down when the dampers are closed tightly.

Edward T. Binns.

Philadelphia, Penn.

[We wish to emphasize the writer's last sentence, for it is hardly to be recommended that the column blowoff be piped elsewhere than to the ashpit. The practice above warned against should be avoided under any conditions but particularly when fresh coal has just been thrown on a hot fire.—Editor.]

QUESTIONS BEFORE THE HOUSE

Slippage of Reciprocating Pumps

Some interesting facts were given by Mervin K. Baer in the article on "The Slippage of Reciprocating Pumps." As this is a question of great moment to all engineers, some actual figures from his tests are appreciated. The writer hopes he will go further into the problem and collect more data, so that he may give a workable formula to use in practice.

The writer has used a formula for pump slippage, which gives results very different from the actual tests recorded in this recent article, but in view of this information he has now abandoned it, and is using an entirely new formula based on Fig. 2 in Mr. Baer's article. This is:

$$s = \frac{\sqrt{P} \times 2000 \times G}{S \times L}$$

in which

s = Percentage of slip;
P = Pounds pressure of the liquid;
G = Specific gravity of the liquid;
S = Piston speed in feet per minute;
L = Length of stroke in inches.

That the valve slip varies inversely as the stroke can hardly be denied, as it is obvious that with the same diameter of barrel and valves, the slip is in proportion to the number of reversals of the valves, and this number is twice as great in a pump of half the stroke, when both pumps have the same piston speed.

When water is being pumped, G need not be considered. The slip is undoubtedly increased with the viscosity of heavy liquids. In sugar-house work we have to pump liquids of densities from that of water to molasses which will weigh 12 lb. per gal. with a density of about 90 deg. Brix. Special pumps are used for this work, but even then it is difficult to force the molasses into the barrel. The valves tend to stick open and they lose their relative weight, so that it is safe to assume the slippage increases in close relation to the specific gravity.

How the factor of specific gravity will work out with oils the writer does not know, having had no experience in pumping liquids lighter than water; but for heavier solutions free from foreign matters, it checks up well with practical work.

The formula is suggested for use within the usual limits of pumping practice as a guide to the slippage to be expected, and an aid in selecting the displacement of the pump required. No formula can give the actual slippage that will be experienced, as this depends on so many things. An outline of the factors controlling the slippage in the valves follows: The length of the pump stroke, pressure pumped against, piston speed, condition of the valve seats, tension of the springs or weight of the valve, height of suction lift, viscosity of the liquid, lift of the valves, shape of the valves and their chamber.

The writer is inclined to the belief that there is more valve slip in direct-acting pumps than there is in flywheel pumps; as the crank pumps do not have the "get away" action of the direct-acting, allowing relatively more time to the valves to "nest home."

The liquid pressure, piston speed and the condition of the valves have been touched on by Mr. Baer. The proper tension on the valve springs has a lot to do with the proper working of the pump, and strictly speaking they should be adjusted and set differently for every condition of service. The higher the pressure pumped against the tighter the springs can be, and the less the suction lift the tighter the suction-valve springs can be. It is an advantage to have the springs as tight as possible for the particular pressure, as the slip is reduced. The nearer the suction water to the pump, naturally the less reduction of pressure in the pump chamber, with consequent reduction of slip in both valves and piston.

The lift of the valves and their general setting should be mentioned. The old-fashioned large valves with the necessary high lift are very little used now, as it is recognized that more valves with low lifts allow far less slippage, and are therefore more economical. The setting and shape of the valves can also affect the slip, as the time of closing will be partly controlled by the way the rush of liquid strikes the valve proper, whether a return rush will aid prompt closing, or by striking it on the side actually tend to retard the closing.

An examination of the formula will give an idea of the relation of the various factors. It may be seen that it is an advantage to have long strokes and high piston speeds with low pressures and specific gravities.

The rise in the curves when the piston speed exceeds a certain amount is not explained by Mr. Baer. He may have data that will throw more light on this point. One explanation is that the rise is due to the choking effect of the suction valves, and so would vary with every pump. There is a certain limit to the velocity at which the water can be forced into the pump by atmospheric pressure, and it is probable that the phenomenon of cavitation causes the increase of slip beyond a certain speed.

Havana, Cuba. CHARLES E. NEWBOLD.

In the Apr. 8 issue of POWER, I was interested in an article on slippage, by Marvin K. Baer, particularly as it refers to a test of pump No. 7 of the Milwaukee waterworks, made in June, 1911, which showed a slip of 43 per cent. After repairs were made to the valves the slip was reduced to 9 per cent.

Insofar as there are no reliable data obtainable on the slippage of reciprocating pumps, I agree with the author's statement, but do not believe that the operating engineers have been indifferent or that they have not made experiments of a practical nature along this line.

In modern pumping stations supplying large cities, the pumping engines are usually of the outside-packed plunger type and if the suction lift is not excessive and the machine properly designed, the main source of slippage would be through the pump valves. I believe from long experience that the average slippage throughout the

year can be kept within a range of from 2 to 5 per cent. for this class of pumping machinery.

Mr. Baer cites a number of tests made on a variety of pumps and gives the slippage, but does not state the instrument used to determine the slippage. The test on pump No. 7 in 1911 was made with a pitometer which was first inserted in the delivery main about 16 ft. from a right-angle curve within the building and at certain portions in the diameter of the pipe showed a minus flow. Another insertion was made just outside the building, which was also found unsatisfactory. Still another insertion was made about 500 ft. distant from the pump. This test was reported to be satisfactory and showed a slippage of 43 per cent. It may also be noted that this pump was not in service when the test referred to was made, but was laid off for the renewal of valves; a leakage was known to exist and reported before the test was ordered. The cause of the leakage was sand getting under the rubber disks, probably coming from a connection previously made to the intake tunnel. Notwithstanding the large slippage reported, this pump, running alone, in taking care of the night demand (which is always uniform) for the high district showed a loss of only 15 per cent. compared with No. 8, a duplicate pump which at the test showed less than 1 per cent. slip.

By men who have made a study of the pitometer, it is usually conceded that when applied to a straight line of pipe of uniform diameter and manipulated with care, the flow may be determined within 2 per cent. Where it is placed near curves or an enlargement or decrease in the diameter of the pipe, the results are not reliable. A certain pipe may be rated at 12, 20 or 30 in. in diameter, but none are absolutely of the required dimensions, depending on the core maker and the manner of pouring the metal in the foundry.

The most reliable method we have found so far to determine the leakage in an outside-packed plunger pump in everyday practice is to put the full water pressure over the suction or delivery valve-deck when the pump is standing idle and examine the leakage of the valves underneath. By this means a practical operating engineer can determine with sufficient accuracy the condition of the valves, as they are liable to leak more under a static head than when in regular operation.

The present administration in Milwaukee has now a practical survey branch of the water service conducted by practical men, which makes a thorough examination of all unmetered services and is beginning to show good results by increasing the revenue. Notwithstanding the large percentage of slip reported, the gallons per capita have been gradually increased from year to year.

1910	gal. per day to population supplied (plunger displacement)	109.0
1911	gal. per day to population supplied (plunger displacement)	111.9
1912	gal. per day to population supplied (plunger displacement)	113.2

This gradual increase has been the experience of nearly all large cities and is due to the extension of large manufacturing industries and not to indifferent operation or pump slippage at the pumping stations. With Mr. Baer, I believe that no hard-and-fast rule can be laid down to determine the slippage of a pump, as the conditions may change in a day or an hour by the displacement or breakage of a valve, and it is not always convenient to shut down even if a leak is apparent. In the Milwaukee waterworks the water delivered is figured slightly below the measured displacement of the pumps, but in making the annual statement the superintendent, in accounting for water, allows 5 per cent. for slippage of pumps. The following is the statement for the year 1912:

	Per cent.
Metered consumption	65.71
Unmetered consumption	9.02
Underregistration of meters	3.00
Slippage of pumps (assumed)	5.00
Water unaccounted for	17.27
	100.00

The unaccounted-for water includes unavoidable leakages in the reservoir, water used for settling trenches in laying 15 miles of water mains and water used for settling about 2000 plumbers' trenches and fire cisterns, all free. The balance is credited to leakage in the distributing system, consisting of 495 miles of water mains from 4 to 42 in. in diameter. It may be seen from the above data that the pump slippage is well within 5 per cent. throughout the year.

THOMAS MCMILLAN,
Milwaukee, Wis., Chief Engineer Pumping Stations.

Safeguarding Economizers

In the issue of Feb. 4, is an interesting editorial entitled, "Why Do Economizers Explode?" The writer having come in contact and examined a great many economizers, thinks a better title would have been, "Why Don't More Economizers Explode?"

It has been my privilege to examine economizers that have been in service for over 30 years and others that were practically new. Many of them were not doing anywhere near their capacity in work, due principally to neglect. It appears to be the general rule in some boiler houses to treat an economizer as though it were merely a feed-water heater instead of practically being a water-tube boiler. I have noted gases entering the economizer chamber at considerably over 600-deg. temperature.

Some economizers are seldom examined or cleaned externally until the soot has banked up around the tubes. Naturally the draft is retarded and an investigation is then made. This neglect is doubtless because the work of cleaning out is so disagreeable and dirty. One way to avoid frequent soot troubles is to go on top of the economizer each day and see that the scrapers are working. If they are not it is only a few minutes' work to release and operate them by hand until they work freely. This has nothing to do with explosions, but it makes it easier to note any defects when an external inspection is made.

An economizer should be thoroughly cleaned out and examined inside once a year and attention given the safety valve at all times. I think there should be two safety valves on each economizer, because the feed water enters it from a heater and as the flue gases pass through the chamber at high temperature there will generally be a larger quantity of scale deposited at the discharge end of the economizer. I have found safety valves partly choked with scale. If there were a second safety valve on the feed-water inlet end it would be quite sure to work because very little scale accumulates at this point. These valves should be tried daily.

The damper nearest the stack should never be tight. An inch play would always allow gases to escape from the economizer when out of service, but the damper nearest the boilers should always be tight. Such a damper

is often made of thin sheet iron, and the hot gases have a tendency to warp it. The same might be said of the flue at the entering end. It is quite common to find that the damper will not close properly because the flue is bulged in at the center. A remedy for this would be to have light iron flues braced on the outside with angle or tee iron near the damper.

Very rarely does an economizer explode while in operation. In any event it would not prove disastrous. If one or more of the tubes begin leaking the water will run into the soot pit where it is readily noticed, if the economizer is located overhead. If the soot pit is below the boiler-house floor, and the leakage cannot be noticed, the fireman can easily tell something is wrong, as the soot becomes damp and will not fall into the soot pit. Instead, it will bake on the tubes and choke the draft.

One of the greatest dangers of an explosion is when an economizer has been laid off and is about to be put back in operation. Then the greatest care should be taken to see that the tubes and headers are cool before filling them with water. After noting that the economizer is full, by opening the vent valve on top, the stack damper should be opened and, lastly, the main damper opened to the economizer chamber.

In summing up, to avoid trouble, first keep the economizers clean; secondly, make frequent examinations and above all see that the safety valves are in good working order.

GEORGE H. HANDLEY.

Newburgh, N. Y.

If the high-temperature feed water did not flash into steam.

If the leakage of gas past the dampers when the economizer is out of service did not occur.

If excessive pressure did not build up in the feed pipe and in the economizer proper.

If scale did not form in the headers and tubes, causing them to become overheated and weakened.

If excessive strains resulting from unequal expansion and contraction did not occur.

Then there would be no economizer explosions.

This is a flat statement to make, nevertheless, I think those familiar with economizer engineering will agree with the writer. Economizer failures can generally be traced directly to one of the five basic "ifs." It should be remembered that the same principle applies to the operation of economizers as to that of steam boilers, and they require the same care and attention. The tubes and surface must be kept clean, inside and out, and when closed down for repairs should be given a rigid inspection. Because of the comparatively high temperature of the feed water, considerable scale-forming matter is precipitated and can be blown off at the economizer. For this reason every economizer should have a mud drum and proper blowoff connection. There should also be a water-pressure gage in the boiler feed-water line, on the economizer side, with a water-relief valve on the economizer to guard against excessive pressure. A feed-pipe pressure of 200 lb. is commonly sufficient. Any sudden rise in the economizer pressure would be quickly detected by the fireman by merely glancing at the gage.

Careful records should be kept of the flue-gas temperature on entering and leaving the economizers. Very high flue-gas temperatures should be avoided. Many plants are producing excellent results with gas entering the economizers at considerably less than 500 deg. I consider a temperature of 260 deg. in the feed water going to the boilers from the economizers as sufficient. In many plants, however, the feed water enters the economizers at 210 deg. and leaves at 270 or 275 deg., and this is considered well within the limits of ordinary operation.

I have operated several large economizer installations and I must admit a disposition to be cautious prompted me to always closely observe the details of their operation. I am convinced that at extremely high temperature the feed water should be handled with care, as the large heat and water-storage capacity of the economizer is a factor to be seriously considered.

Many engineers consider water-tube boilers and economizers immune from serious explosions. This is a fallacy. However, with the exercise of proper care and skill on the part of those in charge of economizers, together with periodical and rigid inspection by experts during construction and operation, economizer explosions should be rare.

Marietta, Ohio. W. M. ALEXANDRE.

In an installation of economizers, with which I am familiar, provision has been made to eliminate, so far as possible, the dangers of an explosion, due to an excessive pressure. The economizers are outside of the boiler house and across the smoke flue leading from the boiler house to the chimney, and are under boiler pressure. The feed water is supplied by an electrically driven triplex power pump.

This pump runs with a variable speed and is under the control of a boiler-house attendant. As one of the three plungers is always on the discharge stroke, there is a steady flow of water, which eliminates shocks to the feed line and economizers.

A relief valve, in the feed line near the pump, prevents an over pressure. This valve is set to open at several pounds higher than the blowing-off pressure of the boilers. Each economizer has a spring-loaded safety valve, so that with the relief valve in the feed lines the danger from excessive pressure should be practically eliminated.

However, the best safety device becomes useless if neglected. The safety valves on the economizers should receive the same as, if not more, care than the safety valves on the boilers, because they are more likely to stick, due to impurities in the water.

The disk should be raised from its seat daily. This is not always done. Sometimes, where economizers have been cut out of service for cleaning, it has been found that the passage leading to the valve, and also the tubes and valve, were covered with a soft scale. If the valve is not opened the scale will accumulate until the valve refuses to operate.

It does not seem to be generally known that an economizer is also a good water purifier. The bad feature is the cleaning, as it is a long, tedious job to remove the scale from the many tubes. Water containing sulphate and carbonate of lime will precipitate impurities when heated to a temperature of 212 deg. F., and as the temperature of the feed water is much higher these impurities are held in suspension, but will gradually settle on the tubes and headers.

EDWIN C. MILLER.

Cleveland, Ohio.

INQUIRIES OF GENERAL INTEREST

Kinds of Direct-Current Generators—Into how many classes may direct-current generators be divided according to the methods used for exciting their fields?

E. H. I.

Three—series wound, shunt wound, and compound wound.

Removing Pump Pistoo—How should the piston of a duplex pump be removed from the rod if a lead hammer will not effect it?

F. S. H.

The piston and rod should be stood up vertically and the joints liberally moistened with kerosene for several hours. Then if the rod cannot be driven out with a lead hammer a countersunk driver should be used over the end of the rod and more powerful blows struck with a sledge. When using a countersunk driver the nuts on the piston rods should be run out to the end of the screw to protect the thread.

Increase of Horsepower—An engine develops 100 hp. when running at 75 r.p.m. with a mean effective pressure of 40 lb. If the mean effective pressure is increased to 45 lb. and the speed to 80 r.p.m., what will be the power developed?

E. H. Q.

The power developed per revolution per minute and per pound of mean effective pressure is

$$\frac{100}{40 \times 75} = \frac{1}{30} \text{ hp.}$$

Then at 80 r.p.m. and 45 lb. pressure it will be

$$\frac{1}{30} \times 80 \times 45 = 120 \text{ hp.}$$

Inserting Boiler Tube—What precautions are necessary when putting a tube in the bottom of a B. & W. boiler?

F. S. H.

Particular care should be taken not to injure the hanging baffle walls or main bridge wall. In expanding the ends of the tubes, especially the rear end, care should be taken to have the tube holes kept dry and clear of all dirt and sediment, so that there may be no leaks at the lower ends when expanded into the header at points not readily inspected while the boiler is in use. In cutting out the old tube and expanding the new tube, the same general precautions should be taken not to injure the tube hole in the header, as always should be done in setting any of the tubes of such a boiler.

Compressor Horsepower—What horsepower is required for a compressor having a bore of 12 in. and a 24-in. stroke, making 72 r.p.m. and delivering against a pressure of 180 lb.?

J. O. B.

The horsepower per 100 cu.ft. of free air compressed per minute may be found from the formula

$$Hp = 1.511\ P_1\ (R^{0.29} - 1)$$

where

P_1 = Pressure of free air, pounds absolute;

R = Ratio of pressures $= \frac{P_2}{P_1}$

where

P_2 = Pressure of delivered air, pounds absolute.

Substituting in this formula

$$\text{Hp.} = 1.511 \times 14.7 \left[\left(\frac{194.7}{14.7} \right)^{0.29} - 1 \right] = 24.775 \text{ hp.}$$

per 100 cu.ft. of free air per min.

From the dimensions given the quantity of free air compressed per minute would be

$$\frac{(12 \times 12 \times 0.7854) \times 21}{1728} \times 74 \times 2 = 203.426$$

cu.ft. per min., requiring

$$\frac{203.426}{100} \times 24.775 = 50.4 \text{ net hp.}$$

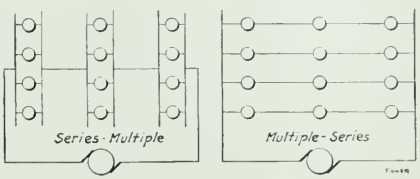
The indicated horsepower required to be developed by the steam end of the compressor would depend on its mechanical efficiency. This for average working conditions would be about 85 per cent., so that the power developed by the steam end would be about

$$\frac{50.4 \times 100}{85} = 59.3 \text{ i.hp.}$$

Combination Electric Circuits—What is the difference between series-multiple and multiple-series as applied to lighting circuits?

E. R. M.

The difference in the wiring is shown in the diagram where in each case the 12 lamps involved are in the same relative positions the better to emphasize the difference in their connections. With all lamps burning the effect is the same with either system of wiring, but in the multiple-series connection the extinguishing of one lamp extinguishes the rest in that series (i.e., in this case the same horizontal line), whereas putting out one light in the series-multiple connection does not put out any others. It does, however, make the other lamps in parallel with it (i.e., the same vertical line in the diagram, burn more brilliantly and the rest less brilliantly. The reason is that the combined current which passes through four lamps in parallel must go through three lamps in the circuit where one has been extinguished, and, conversely,



only the current which can get through the three lamps is available for the four-lamp groups. If all but one or two lamps should be extinguished the remaining lamp or lamps would be likely to burn out. For this reason this system of connections should generally be avoided unless conditions are such that excess current through any lamps is unlikely.

Water-Power Calculation—What horsepower will a stream of water deliver, entering an 8-in. pipe 2 in. below the level of a lake, with a head of 20 ft., using a common low-pressure turbine?

E. R. F.

The most water that could get into the pipe would be that due to a head of 6 in. (lake surface to center of pipe) entering an aperture 8 in. in diameter, for if the head of 20 ft. in the pipe, by suction, tended to draw the water in faster, the surface of the water immediately over the pipe would cavitate and air would be drawn into the pipe.

The velocity of flow in feet per second is expressed by the formula

$$V = \sqrt{2gh}$$

in which

$2g = 64.4$

h = Head in feet $= 6 - 0.5$ ft.

Then

$$V = \sqrt{64.4 \times 0.5} = 5.67 \text{ ft. per sec.}$$

The cross-sectional area of an 8-in. pipe is 50.265 sq.in. or 0.349 sq.ft.

Based on experiments with a variety of weirs and apertures, the coefficient of discharge may be assumed to be 62 per cent. for the conditions in this case. Then the water passed by the pipe would be

$$5.67 \times 0.349 \times 0.62 = 1.2269 \text{ cu.ft. per sec.}$$

or

$$1.2269 \times 62.355 = 76.5033 \text{ lb. per sec.}$$

or

$$76.5033 \times 60 = 4590.198 \text{ lb. per min.}$$

With a head of 20 ft. this would develop

$$4590.198 \times 20 = 91803.96 \text{ ft.lb. per min.}$$

or

$$\frac{91803.96}{33,000} = 2.78 \text{ hp.}$$

As ordinary good lowhead turbines have an efficiency of 75 per cent. the actual or brake horsepower realized would be

$$2.78 \times 0.75 = 2.09 \text{ b.hp.}$$

ENGINEERS' STUDY COURSE

Analysis of Coal—III

Making the Analysis

You have now been introduced to all the apparatus needed in making a proximate analysis and all that remains to be acquired is a little practice in handling the equipment and running the actual analysis. Run five or six analyses just for the practice.

From the outset, remember that the more careful and painstaking you are with the work, the more accurate and reliable will be the results. The sample dealt with, one gram, and the differences to be determined in the weight of that sample after each step, are so small that it requires but a slight inaccuracy to throw out the entire work.

Get into the habit of following exactly the same process with each analysis. Do not use one method one day and then vary it, even slightly, the next. Decide by experiment in the beginning the best method for you to follow and stick as closely to that method as possible with all your analyses. The object of this advice is to insure uniformity in results. If you use one method one day and a slightly different method the next, the results are not likely to be uniform. And what you want is a fair comparison, one day with another.

A good method to follow is this: Assume that a 5-lb. sample of the coal to be tested has been collected as described in Part 1. Rule off a form on which to record the analysis. The one shown, already filled out, in Fig. 9 is convenient but may need slight modifications to suit special needs. If you expect to analyze coal regularly, it will pay to have the form printed or mimeographed.

First, see that the crucible is thoroughly clean and dry. Then weigh it, together with its cover, as accurately as possible, remembering to test the balance first. Weigh the crucible and cover before every analysis, to be sure that the weight is accurate, for if a slight chip should break off from either, the results would be wrong unless the new weight of the crucible were used. Enter the weight in the proper space on the report sheet. Then, fill out the first space by adding one gram to the weight of crucible and lid.

When weighing it is not necessary to wait for the balance to come to rest each time; simply notice whether the pointer swings uniformly a given number of divisions each side of the center line on the scale. But be sure that the swing is exactly uniform. Leave the crucible in the scale pan ready to receive the sample.

Spread out the 5-lb. sample on a clean surface (such as a piece of newspaper) mix thoroughly and quarter down to about one pound. Put this quantity through the coffee mill once or twice, grinding as fine as possible with the mill. Again mix and spread out thin on a clean surface. Then, with a knife blade, select small quantities from a half dozen places in the mass and put them in the mortar, thus obtaining about one ounce. Crush thoroughly with the pestle. Sift this finely crushed sample through the 100-mesh sieve into the tray that comes with the latter. If any of the sample will not pass through, put it back into the mortar and crush until practically all passes through.

If you are working without a sieve be sure that the sample is crushed fine enough. It should look like a very fine dust—so fine and uniform that no individual particles are distinguishable.

Now, add one gram to the weights in the balance and put enough of the powdered sample into the crucible to again restore equilibrium.

Put the crucible (without cover) into the oven and heat to 110 deg. C. for one hour. Keep heat as uniform as possible. Now, quickly transfer the crucible to the desiccator and allow it to cool off. This will take about 10 min. When cool, weigh crucible (with lid) and enter weight in the second space on the report sheet. Subtract this weight from the one above, move the decimal point two places to the right and enter result as percentage of moisture in the proper space.

Next, place the crucible, with lid on and in an upright position, on the triangle and ringstand over the burner, as shown at the left in Fig. 2. Turn the flame up strong and heat the crucible for full 7 min. The flame should be long enough and placed close enough to the crucible to completely envelop it and shoot above for a distance of an inch or more.

At the end of the 7 min. remove the flame and transfer the crucible and lid to the desiccator to cool. Inspect the sides of the crucible to make sure that the porcelain insulators on the triangles have not softened under the heat and left small particles sticking to the former. If this occurs the analysis will have to be done over, as the weighing would be inaccurate. If this occurs frequently, a "Nichrome" wire triangle will have to be used instead of the porcelain insulated one. The cost of one of this kind is about 35c., but it is durable and will not stick.

In heating to drive off the volatile matter a black smudge of carbon will probably be made on the outside of the crucible. Most people burn this off before transferring to the desiccator by playing the flame on the sides. I am not going to advise you to do this because unless carefully done, it leads to the breakage of crucible or lid, thus spoiling an analysis. Besides, the error caused is so *very* slight that it is hardly worth the trouble taken to eliminate it, and, if the same practice is followed each time, the importance of the error is still more reduced. However, before another analysis is made in the crucible both it and the lid should be cleaned by carefully burning off this carbon deposit.

When the crucible is cool, weigh and enter the weight as before. The loss in weight this time represents the percentage of volatile matter contained in the coal.

Next, place the crucible, without cover, on the stand again, only this time, tilt it as far on its side as you can without danger of any of the contents being spilled or blown out. Turn the flame on strong, as before, and heat thus for at least two hours. See that the flame concentrates under that part where the sample lies.

At the end of the heating, cool in the desiccator and weigh again with the lid. The loss in weight this time represents the percentage of fixed carbon. And, the difference between this last weight and the weight of the empty crucible with lid represents the percentage of ash in the coal.

The analysis is now finished and all that remains is to stow the apparatus safely away until next needed and to calculate the analysis of the dry coal.

The analysis which we have just completed is that of the coal "as received." Strictly speaking, it is not the true analysis of the coal as received because some of the moisture dried out while the sample was being prepared for testing. But, as long as about the same length of time is taken up in preparing the sample in each case and as long as the process of treatment is the same, the error remains about the same and, so, we may call it the "as received" analysis and do no particular harm.

With some grades of coal which have a great capacity

PROXIMATE ANALYSIS OF COAL

Plant Progress Mine No 6

Car Nos. C. & E. I. 74431, A. & R. 14865 Total Tons in Shipment 80

Date Received Jan 7, 13 Date Sample Taken Jan 7, 13 Date Analyzed Jan 10, 13

Analyzed by Harvey Wade

	Grams		Analysis of Coal as Received	Analysis of Dry Coal
Wt. of crucible and lid plus sample	21.522			
Wt. less moisture	21.445	Per cent. moisture	7.7	
Wt. less volatile matter	21.167	Per cent. vol. matter	27.8	30.12
Wt. less fixed carbon	20.637	Per cent. fixed carbon	53.0	57.42
Wt. of empty crucible with lid	20.522	Per cent. ash	11.5	12.46

Heat value of dry coal (by calorimeter) ..... B.t.u. per lb. Cost of Coal, $ 2.90 per ton

Heat value of combustible (estimated) 15275 B.t.u. per lb No. B.t.u. purchased for 1 cent 5567.6

Heat value of dry coal (estimated) 13457 B.t.u. per lb.

Heat value of coal as received (estimated) 12422 B.t.u. per lb.

Fig. 7. Proximate Analysis Report Form

for absorbing moisture it is necessary to air dry the sample before it can be passed through the sieve. In such cases if extreme accuracy is important, a preliminary air-drying test must be made and the moisture thus eliminated must be included in the calculations. But as this complicates matters somewhat, I do not recommend that it be attempted in ordinary work. If the coal will not sift through the sieve readily when first crushed, it may be allowed to stand exposed to the air for one-half to one hour. A better method to employ, because it insures more uniform analyses, is to coarse grind a sample of a pound or two in the coffee mill, spread it out in a thin layer and leave it exposed to the air at 70 to 80 deg. F. for 24 hours. If this method is adopted regularly, the term "air dried" should be substituted for "as received" throughout the report form in Fig. 7.

To figure the analysis of the dry coal from the analysis of the "as received" sample, simply divide the percentage of volatile matter, fixed carbon and ash (each in turn) by the sum of all three. Thus, taking the analysis given in Fig. 7, the sum of the percentages of volatile matter, fixed carbon, and ash is,

$$27.8 + 53 + 11.5 = 92.3$$

This sum divided into the percentage of volatile matter gives

$$\frac{27.8}{92.3} = 30.12$$

as the percentage of volatile matter in the dry coal.

The reason is simple. Let us assume 100 lb. of coal of the analysis given. As the analysis shows 7.7 per cent. moisture, 7.7 lb. is water, leaving only 92.3 lb. when the coal is thoroughly dry. The analysis also shows 27.8 lb. volatile matter in every 100 lb. of the coal as received. Then, what fraction of the dry coal is the volatile matter?

$$\frac{27.8}{92.3} = 0.3012 \textit{ or } 30.12 \textit{ per cent.}$$

In a like manner, the percentages of the other two constituents, fixed carbon and ash, are figured.

Lighting the Panama-Pacific Exposition

The Panama-Pacific International Exposition is scheduled to open Feb. 20 and continue until Dec. 4, 1915, while the Panama Canal, which it commemorates, will be officially opened in full running order by the Government on Jan. 1 of that year.

As the canal will afford a new trade route for the commerce of the Eastern and Western Hemispheres, the question of devising a scheme of decoration and illumination that would not only distinguish the exposition as unique among its kind, but also typify in a measure the conditions of both the Orient and the Occident, seemed of utmost importance. W. D'Arcy Ryan, director of the illuminating laboratory of the General Electric Co., was appointed to undertake the commission. Something new in lighting was the general request, and it is Mr. Ryan's intention not to use a single piece of lighting that has ever been used before. There will be no dazzling white exposition or outlining of buildings with incandescent lamps. It is the intention to make the exposition a city rich with color. The ground tones will be about the color of travertine stone, intensified by lighting to an ivory yellow, which will appear almost white from a distance. Distinctive tones, so regular that they will blend in varied harmonies, Pompian red, strong Italian blues, vermilion and orange tones will be employed in the special color scheme.

The exposition grounds contain 625 acres in the harbor-view section, forming a natural amphitheater overlooking San Francisco Bay. In composition the architectural plan consists of three principal elements, that of the center being the main group of exhibit palaces and the other two elements balancing on either side. To the east lie the amusement concessions, while to the west lies the small city of foreign government pavilions and state buildings. The main exposition palaces occupy over 100 acres, covering an area over 1000 ft. long by 1200 ft. wide. The central block is divided by three magnificent courts developed longitudinally north and south. They are called the Festival Court, or the Court of Abundance, the Grand Court of Honor, or the Court of the Sun and Stars, and the Court of the Four Seasons. The Court of the Sun and Stars will stand out as a brilliant architectural expression distinguished by the majestic scale of its architecture and the splendor of its color

effect. The tower at the southern entrance will be studded with 50,000 jewels, diamonds, topazes, rubies and sapphires, which will sparkle at night in the rays from batteries of searchlights. Jewels will also be used wherever they can add to the beauty of an architectural line or surface or sculptured form. They will be suspended upon delicate springs, so that the least vibration from the wind or machinery or even the tramping of feet may keep them in constant motion and set them flashing.

In the court will be two immense fountains, one signifying the spirit of the East, and the other the spirit of the West, brought together through the Panama Canal. At night the court will be illuminated from the fountains. They will be constructed of dense white glass, and within each will be concealed 72 luminous arc lamps. When the arcs are lighted the entire surface of the fountain will become luminous, flooding the court with a softly diffused white light.

In the courts there will be various great mural paintings, which will be illuminated by concealed lamps set into the pillars fronting them, a special tubular lamp having been perfected for the fluted columns. The lamps and reflectors are made small enough to insert into the flute, and on smooth columns three lamps will be inserted at heights of about 10, 20 and 30 ft., and partially concealed by reflectors. The illumination on the paintings will be controlled in intensity by changing the size of the units and the curvature of the reflecting surfaces. By introducing colored bulbs any color effect may be obtained.

Throughout the grounds ornamental luminous arcs will be used and fitted with dense globes, so that it will be possible to look at them directly without injury to the eye. Inclosed-flame arc-lamps will be used extensively for indoor lighting.

There will be electric fountains, but no water will be used; instead, smoke and steam will be sent into the air, and will glow from the rays of the scintillator. A locomotive mounted on a steel turntable will supply the smoke and steam. If experiments now being made prove successful, thousands of large soap bubbles will be released from a large blower and float into the air to pass through the rays from the searchlights. Quantities of cloth balls will also be sent up into the air and will glow with ever-changing color combinations in the projected beams of colored light.

The large electric scintillator, which will be anchored on barges in the bay 500 yards from the shore, will consist of a battery of 48 searchlights aggregating over four billion candlepower and have 36-in. parabolic mirrors. The lights represent the 48 states, and will require 60 men to operate them.

That the exposition in its entirety will leave a lasting impression of its greatness and grandeur on the many thousands of visitors, both from this country and abroad, is assured. It will be a fitting and adequate expression of the opening of the new great way to the East and the West. But the impression of newness that will charm and linger long with the visitor, will be the combined decorative and lighting scheme.

⁂

The energetic fight being made for new business by the Quebec Railway, Light & Power Co. and the Dorchester Electric Co., of Quebec, is reflected in the reduction of rates made by the former company from 15c. to 7c. per kw.-hr. The Dorchester Electric Co. announces its intention of meeting the cut by making its base rate for energy 6c. per kw.-hr.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"What becomes of the water?" asks a correspondent. Why, the hydro. people utilize a good-sized bunch of it; some of it is tucked away in boilers and dams; it's sometimes used for bathing purposes; some people have been known to drink it; and— Say, what are you trying to do, anyhow; kid us?

⁂

Horace Darwin, the British aëronautic expert, says that "if the birds knew how, they would copy the Wright biplane." The birds know too much already, Hoddy. Wish you'd been with us to the band concert in the park last Sunday afternoon. We sat under one of those Longfellow spreading chestnut trees, and our new straw kelly with the green bow in the back was— On second thought, we agree with Hoddy that the birds ain't got the (W)right idee.

⁂

"He lighted his pipe and then sat on his chest," contends a magazine-story writer. In our kid days we sneaked under the flap of the circus tent and witnessed some thrilling contortions, but we can't quite figure out this chest stunt.

⁂

Glad to know that somebody can get away from old man Consequence. A correspondent in the "Engineering and Mining Journal" says that one of the qualifications of a consulting engineer is "a diabolical ingenuity in escaping consequences." Anyone step on your ingrowing toe nail, sonny?

⁂

Bully publicity work is being done by the National Association of Building Owners and Managers. When it starts out to do anything, people hear about it and all about it. Some corking good papers are promised for the Cincinnati convention on office-building power-plant operation, smoke abatement, furnace operation, etc., written by "the man on the job." When you know something good, holler about it" is pretty near the size of their slogan.

⁂

The scarcity of garbage cans in Hickman, Ky., prompted the local electric-light and ice company, when it bought new ice cans, to give the old ones to the city for garbage repositories. This is a very pretty sentiment coming from a central-station company. It might have sold them but no, Hickman "suffered considerably" for garbage cans, and (another touching sentiment), as the "Electrical World" says, the cans will "serve as a constant reminder of the desire of the company to coöperate wherever possible for the good of the community." You wouldn't think a garbage can could awaken such kindly sympathy and generous action!

⁂

S. Kirlin's been curlin' up a few with a laugh in 'em. If you think they're a leetle out of focus, you've mistaken, for he's photographing for the Ioway trade, and you can't fool Ioway when it comes to pictures—or jokes. Read 'em!

Jimmy Maloney, th' little feller thet iles over to th' power house hit th' chief fer a day off one day last week; sed his grandma hed died an' he hed to help bury her.

Th' chief told him he'd let him off this time, but he'd noticed thet th' old lady hed a habit uv doin her dyin' act every year just before th' day uv th' openin' game on th' home grounds an' he wished Jimmy wud arrange with her to put it off 'till some other time, an' it might not be necessary fer him to hev to help bury her.

Old Hal Mossback's biler busted t'other day an' blowed Hal clean over th' hobble skirt factery an' he kum down straddle uv a telephone cable in front uv Hennessy's booze emporium.

Th' boss told him he reckoned he jist went in that direction 'cause he'd got used to doin' it.

Bill Grimes ast Hal how it felt to git blowed up. Hal sed he didn't notis anything unusual 'bout it; sed he'd bin stayin' down town late nights fer a spell an' th' old lady hed sorter got him used to it.

Sid Diggles ast th' Boss ef he cud git out uv th' ingin room fer a spell while he went to git married.

Th' boss hummed an' hawed fer a spell, an' then told him thet he cal'lated he cud do it this time, but not to let it happen too often.

Experiments on Efficient Boiler Operation

By B. W. Rogowski

SYNOPSIS—An account of the change made in a boiler plant to improve the efficiency. An analysis of flue gases showed a gain of from 6 per cent. to 11.8 per cent. CO_2.

More preventable losses were occurring in our boiler house than at any other part of the power plant. Experiments were conducted to determine such operating conditions as would reduce these losses. The steam-generating equipment consists of nine boilers, representing four types whose aggregate rated capacity is 2600 boiler horsepower. The reciprocating engines have a capacity of 2600 hp.

The processes of combustion were analyzed and it was determined that the heat losses attending the combustion of fuel were:

Loss in the dry chimney gases,
Loss due to incomplete combustion,
Loss of fuel through grates,
Moisture in the fuel and air,
Loss due to the presence of hydrogen in the fuel,
Unburned fuel in the form of soot or smoke
Radiation and other secondary losses.

The greatest loss is the heat carried away by the escaping chimney gases, part of which, usually, is preventable. The total loss in the dry chimney gases in best practice averages 25 per cent. of the total heat generated from the fuel; always, however, a loss of approximately 10 per cent. of the total heat value of the fuel is unavoidable and represents the cost of moving the gases. This loss was calculated as follows:

Assume the air supply to be theoretically correctly proportioned to the amount of coal burned, i.e., 11.5 lb. per pound of combustible; atmospheric temperature, 60 deg. F.; stack temperature at the base, 450 deg. F.; specific heat of the flue gases, 0.24. Then the heat carried away by the least possible weight of chimney gases with perfect combustion and the conditions specified above would be

$$(11.5 + 1) \times (450 - 60) \times 0.24 = 1170 \text{ } B.t.u.$$

With fuel having a calorific value of 12,500 B.t.u. per pound this means an unavoidable loss of

$$\frac{1170}{12{,}500} \times 100 = 9.36 \text{ } per\ cent.$$

The remaining 15.69 per cent. loss is due to the excess air necessary for complete combustion. This represents from 50 to 100 per cent. excess air.

For any boiler installation the most economical percentage of excess air depends upon the size and nature of the fuel, the thickness of the fuel bed, the frequency of cleaning, the intensity of draft and the character of the grate. Although the loss in the best practice, due to excess air is 15 per cent. of the total heat content of the fuel, it often is as high as 40 per cent.

By determining the fuel value of ashes it was found that the loss of fuel through the grates was approximately 3 per cent. of the calorific value of the fuel. No. 1 buckwheat coal was burned on stationary grates of the herringbone type, with air spaces ⅜ in. wide. The presence of about 8 per cent. of moisture in the fuel is equivalent to a loss of 1 per cent. of the total heat value of the dry fuel for the average conditions of the plant.

The fuel loss through the grate bars and that due to the moisture in the coal were, however, regarded as inappreciable compared to other existing losses which were about to be attacked. We began by studying the operating conditions, leaving the correction of any appreciable losses due to fixed conditions for a later date.

We realized that economy in the boiler room depended largely on the choice of coal adaptable to the plant conditions and which would generate the greatest amount of heat at the lowest cost for handling and consumption. Also to provide operating conditions which would permit of the coal being burned with the highest commercial efficiency.

We were justified in using No. 1 buckwheat as our grates had a 25 per cent. air space, making them satisfactory for this small size of coal. The furnaces are wide and deep with a high ratio of grate area to the heating surface.

The stacks are 150 ft. high and the draft at the base is 1 in. of water. Auxiliary draft is provided by turbo-undergrate draft fans. The firemen are skilled and intelligent. The boiler load curves are such as require a coal consumption of approximately 17 lb. per square foot of grate area per hour.

Several furnaces had flexible air-cooled and self-supporting arches. Since No. 1 buckwheat is very low in volatile matter, 6 per cent., it requires relatively little surface air and the air inlets to the arch must be adjusted accordingly. Each boiler setting was tested for tightness, first by candle flame and then by burning very smoky fuel in the furnace, shutting off the damper and all ordinary connections of the furnace to the atmosphere, when the smoke issued from the crevices. Two boiler settings were found very leaky and, before making repairs, samples of the flue gas were taken and analyzed, resulting in 6 per cent. CO_2, 14.2 per cent. O_2 and 0.9 per cent. CO. The stack temperature at the base was 790 deg. F.

After resetting the boilers, the enormously high stack temperature was found to be caused by heavy deposits of soot. Soot blowers were installed on a 350-hp. hand-fired water-tube boiler, which was receiving attention, and the sample of flue gas taken gave an analysis of 11.8 per cent. CO_2, 8.8 per cent. O_2 and no CO. The temperature at the base of the stack was 525 deg. F.

These results show an enormous increase in the rate of heat transfer and consequently in boiler efficiency brought about by cleaning the tubes. Methods of firing were next investigated. The practice was to carry thin fires, fire frequently and to cover the entire fuel bed at one time. The furnaces have four firing doors.

Experiments with the thickness of the fuel bed were made, for it was evident that, having established the quality and size of fuel and the intensity of draft, there was a certain depth of fuel for each furnace which would give the most efficient results. After many experiments, over a long period, a 1½-in. bed was found most efficient, on herringbone grates with a draft at the base of the stack of 1 in. of water and that the fuel thickness corresponded to a coal consumption of 18 lb. of coal per square foot of grate surface per hour. The fuel bed was thickened, firings were ordered to occur less frequently

and the results indicated a further increase in economy, due to a good setting, clean heating surface and an efficient thickness of fuel bed.

Analysis of the flue gas still indicated a trace of CO. Desiring to make combustion more complete, alternate firing was tried, i.e., firing only one side of the double furnaces at a time; this gave the desired result. The incandescent bed on one side of the furnace appeared white or very faint yellow and the excess air was highly preheated in passing through it. The other side of the furnace contained the bed of green coal and this appeared blue when CO was being generated and burning.

The combination of this highly preheated air and carbon monoxide at the bridge-wall secured complete combustion. An abstract of the log indicates the effect upon flue-gas analysis and stack temperature of various conditions and devices introduced.

Flue Gas Analysis Per cent. of Volume CO_2	O_2	CO	Stack Temperature, Deg F.	Remarks
6 0	14 2	0 9	790	Conditions when experiments were undertaken
7 2	10.0	0 0	760	Clinker removed; fire cleaned excess air reduced by removal of ash.
12 00	4 0	0 0	625	Fuel bed thickened, damper ¼ open, both sides of furnace fired at once.
13.0	4 0	0 0	600	Tubes blown, same condition as above.
9 8	8 2	0 4	590	Just after covering both sides.
9.4	10 4	0 0	550	Air holes 6-4 in. dia. holes opened wide; tubes in clean condition
10 0	7 5	0 0	500	Air holes normal sizes, ¼ in. dia.
14 0	3 0	0 0	470	Air holes closed almost entirely, tubes just blown; thickened fuel bed.

Observations show, and the general conclusions are, that the most efficient method of firing double furnaces with anthracite coal is to fire each side separately and at alternate intervals. The method known as "spot firing" has been established as standard here. The frequency of cleaning depends upon the rapidity of combustion and upon the percentage of ash in the fuel. For the conditions outlined, two cleanings in ten hours have proved most satisfactory.

As anthracite coal tends to break up into fine fragments when burning, the fire must not be disturbed except when cleaning, or the percentage of unburned fuel in the ash will be excessive. The luminosity of the flame at the first bank of tubes may be regarded as a fair indicator of the proper thickness of fuel bed. A luminous flame is one in which incandescent carbon exists and its presence in the flame indicates too little air for good combustion; the fuel bed must be thinner, or a readjustment of the surface air will be necessary.

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It is perhaps not very well known that altitude has its effect upon machinery as well as upon the human being, particularly upon the efficiency of gas and oil engines, says *The Isolated Plant*. The atmosphere is so thin, comparatively, that a given compressing stroke of the piston of the gas engine results in much less compression and in this manner the engine loses in efficiency. Also the smaller amount of oxygen in the cylinder results in a smaller consumption of the residue in the oil engines.

An engine that in Chicago, St. Louis or New York had produced 75 hp. could do no better than 40 hp. in South America, where the altitude was 11,000 to 13,000 ft. above sea level. To obtain the 75 hp. it would require an engine of 110 hp.

The rarer atmosphere also makes necessary an essentially different construction in electrical devices.

American Society of Mechanical Engineers' Baltimore Meeting

Disappointingly small was the number in attendance, not quite three hundred, at the meeting of the American Society of Mechanical Engineers in Baltimore, Md., May 20 to 23. After the elaborate and painstaking preparations made by the local engineers to entertain the society it was regrettable more were not there. The approaching joint meeting in Germany with the Verein Deutscher Ingenieure kept many away from Baltimore for the party will sail June 10, only a little more than two weeks after the close of the Baltimore meeting.

The professional sessions were of considerable general interest, but only one of the papers was of much real moment to the power field—"Present Operation of Gas Engines Using Blast Furnace Gas as Fuel," by Charles C. Sampson of the Illinois Steel Co. A rather full abstract of this paper will appear in the Gas Power Department of the next issue.

The principal discussion was offered by Frederick C. Wagner, which referred especially to gas cleaning and described two successful cleaners used abroad, the Feld and the Schwartz cleaners. More concerning this discussion will be given in a later issue.

The meeting was opened Tuesday evening in the tea room of the Hotel Belvedere with an informal reception by the officers of the Engineers' Club of Baltimore. An address of welcome was made by the mayor, and response for the society, in the absence of President W. F. M. Goss, by Past-President Oberlin Smith. R. Keith Compton, president of the Engineers' Club of Baltimore, presided and a short account of the engineering history of Baltimore was given by Mendes Cohen, a veteran engineer of the city.

Wednesday

The business session convened Wednesday morning. Some time was spent discussing a proposed code of ethics for engineers and a good deal of difference of opinion was brought out; first, as to whether a need for one existed; second, if there was one, if it would be respected and followed by the profession; other points were taken up regarding individual clauses in the proposed code. So great were the differences of opinion regarding it that it was finally decided to submit the code to the entire membership by letter ballot and, when definite recommendations could be made, to submit a code to the Council for action—preferably adoption.

The desirability of adopting the myriawatt (10,000 watts) as a standard unit of power, first advanced by H. G. Stott and Haylett O'Neill last year, as noted in Power, Aug. 27, 1912, was defended by Mr. Stott against the criticisms offered by Willian Kent and George H. Barrus. Against the argument that introducing a new unit only added to the number in use and complicated rather than simplified matters, Mr. Stott indicated that the myriawatt is not a new unit but a little-used multiple of an old one that would be more convenient to use than horsepower and has the advantage that its value very closely coincides with one boiler horsepower. More concerning the discussion of the myriawatt will appear in a later issue.

In presenting his paper on a "Test of a Hydraulic

Buffer," Carl Schwartz used the lantern and showed views of the installation of hydraulic buffers for arresting trains in the Grand Central Station and curves plotted to show the pressure built up in the buffers in given elapsed periods when a train impacts on a buffer.

Edwin J. Prindle called attention to a matter of much concern to many, namely, the present danger of a modification of the patent laws that will divest the inventor of rights he now enjoys, and in the author's opinion, to which he is justly entitled. His paper outlined the cases which had brought up the matter of new legislation and showed the dangers in the anticipated enactments. It was urged that the society as a body and members individually communicate with congressmen and protest against the measures now in prospect of being adopted. A vote was passed that the Council be requested to forward such an official protest in the form of resolutions.

Theodore W. Johnson in his paper, "Shading in Mechanical Drawing," offered rules for making the practice standard.

"Cost of Upkeep of Horse-Drawn Vehicles Against Electric Vehicles," by W. R. Metz, brought out the most valuable kind of information in relation to trucking. Experience in the comparative costs of the two modes of transportation is the best guide to those contemplating a change of equipment. The author's conclusion was that motor-driven vehicles are unquestionably cheaper than horse-drawn vehicles where a number are used and that the only question is to decide between electric and gasoline trucks. Electric trucks seem to cost less to maintain, but gasoline trucks have a greater radius of action.

In the afternoon the city fire department gave a demonstration of the high-pressure fire system. Two motor wagons with three streams each were supplied with water from a single combination outlet under a pressure of between 250 and 300 lb. The pumping station was also inspected.

After this a sail around the harbor was taken on the municipal steamer, "F. C. Latrobe." While passing the fire boat "Deluge," the latter was put in action, throwing eight streams simultaneously.

A fascinating lecture, entitled "Around the World in Eighty Minutes," was delivered by the Hon. O. P. Austin, secretary of the National Geographic Society, in the evening. It was profusely illustrated mainly with moving pictures taken in all parts of the world.

Thursday

The entire session Thursday morning was given to the subject of Fire Protection, except for a recess while honorary membership was conferred upon Captain Charles H. Manning,* inventor of the Manning boiler, a retired engineer officer of the U. S. Navy, and until recently mechanical engineer of the Amoskeag Mfg. Co. In his response accepting the honor and expressing his appreciation, Captain Manning indulged in some reminiscences of his early engineering experience that were extremely interesting.

James B. Scott, with lantern slides, described "The Baltimore High-Pressure Fire Service;" F. M. Griswold presented the subject "National Standard Hose Couplings and Hydrant Fittings for Public Fire Service," calling attention to the present differences in diameters and threads used and how they could easily be harmonized. Albert Blauvelt discussed "Debarment of City Conflagrations," Ira H. Woolson, "Allowable Height and Area in Factory Buildings," (a summary of the result of a letter campaign among fire chiefs and fire marshals); C. H. Smith, "The Protection of Main Belt Drives with Fire Retardent Partitions," and H. F. J. Porter, "The Life Hazard in Crowded Buildings Due to Inadequate Exits."

The usual resolutions of thanks were passed to all concerned in the entertainment of the society and its guests.

The afternoon excursion Thursday was an inspection of the work on the new sewer system, including the Jones Falls conduits, the sewage pumping plant and the sewage-disposal plant at Back River.

In the evening the Engineers' Club of Baltimore tendered a reception and dance to the Society's members and guests in the ball room of the Hotel Belvedere.

Friday

Friday was spent at Annapolis. By high-speed interurban electric cars, the party was conveyed from Baltimore to Annapolis and upon arrival there was received by Governor Goldsborough in the senate chamber of the state capitol building. President Goss responded to the welcome of the Governor. Admiral H. I. Cone then addressed the gathering on the subject of the the Naval Experiment Station, stating something of the work it has done and is doing.

After a short walk around the town to see the places of historic interest the visitors assembled at Carvel Hall Hotel (originally the home of William Paca, one of the signers of the Declaration of Independence, where luncheon was served.

All of the afternoon was spent in the buildings and about the grounds of the Naval Academy. At the aviation camp, particularly interesting was it to see at close range the hydro-aeroplanes with which the naval officers have been having such great success. President Goss and a few other members of the society had the privilege of the experience of a short flight in the machines.

Also of special interest was the Naval Experiment Station in command of Capt. T. W. Kinkaid. Here a number of important investigations are just now in progress, including corrosion of metals, boiler compounds, lubricants, tests of sheet and rod packings, tests of valves, tests of gage glasses, tests of pressure regulators, feedwater and air heaters, evaporators and distillers, experimental steam turbines, forced-draft blowers, heat-transmission investigation, boiler tests with oil fuel, boiler tests with coal fuel, condensers and air pumps, centrifugal and rotary pumps, safety valves and calorimetry and specific heat.

Unfortunately rain interfered with some of the late afternoon program, for it had been planned to have a dress parade of the midshipmen with music by the Naval Academy band. The inclement weather sent most of the party back to Baltimore rather earlier than intended.

Altogether the meeting, while perhaps not one of the most remarkable the society has held in point of importance or great value of the papers presented or discussion drawn out, was nevertheless a very enjoyable one, and unusually well planned and conducted by the local engineers responsible for the entertainment.

*An account of the life of Captain Manning may be found in "Power," May 16, 1911, page 760

Annual Report of Topeka's Lighting Plant

SYNOPSIS—Operating costs of a small municipal plant carrying a lighting load. The system of records is unusually complete and includes all details of line and plant.

As a basis for comparing the operating cost of a plant year in and year out there is nothing better than annual reports made up from the daily and monthly records of the plant. As an example which may be of general interest, we are reproducing in part the annual report on the municipal electric-lighting plant at Topeka, Kan. The report was issued by G. G. O'Neill, superintendent of the plant, and is unusually complete in all details.

In 1889 the city of Topeka purchased the lighting plant and in 1908 bonds to the amount of $65,600 were voted to rebuild the plant. Of this, $40,000 was used to install the Cooper-Hewitt constant-current mercury rectifier system with the Westinghouse metallic flame arc lamps. The value of the plant is at present approximately $65,000. The equipment is as follows: One Murray Corliss steam engine, 26x48 in.; one 260-kw. alternating-current Westinghouse, three-phase, 60-cycle generator; one 100-lamp, two-circuit Cooper-Hewitt rectifier set; three 75-lamp, one-circuit sets; five 50-lamp, one-circuit sets; one two-panel switchboard, instruments, etc.; three 18-ft. by 72-in. Bromich return-tubular boilers; one Sorge Cochrane open feed-water heater, and one 6x4x6-in. Advance hot-water feed pump.

On Dec. 31, 1912, the load consisted of 439 arc lamps, 70 series tungsten, and 785 one hundred-watt and 60-watt lamps for the White Way on Kansas Ave., West Ninth St. and East Fourth St. On Kansas Ave. each post of the White Way contains five 100-watt, upright lamps, totaling 400 cp. On the other streets of the White Way the posts have five upright lamps, the top being 100 watts, and the arm lamps 60 watts. Each post totals 292 candlepower.

The report gives in detail the operating conditions of the plant, conditions of the lines, cost per kilowatt-hour to generate current, cost per arc lamp, and White Way or special lighting costs, a comparison with other cities, also receipts and disbursements of the light department.

During the year 1911 a complete outfit of recording meters and instruments was installed in the plant, whereby the electrical output and working conditions could be ascertained. A set of scales was also installed for the weighing of coal. Beginning Jan. 1, 1912, a complete set of station charts was installed, consisting of a station log chart, engineers' supply chart, fuel record, chief lineman and trimmer chart, so that it was possible to keep a close record on the operating conditions. A set of books was also opened, consisting of a journal, ledger and trial balance. A summary of the data obtained is given in the accompanying table:

Operating fund	$16,293 26
Special lighting of White Way	3,077 09
Reconstruction fund	73 79
Total for year	$19,444 14

SPECIAL LIGHTING

Maintenance of Kansas Ave., White Way	$1,570 70
Maintenance of Fourth St., White Way (60 days)	178 07
Maintenance of Ninth St., White Way (83 days)	8 41
Installing special lighting	736 42
Cost to run feeders to and connect Fourth St.	395 99

SUMMARY OF ARC-LAMP DATA

Cost per arc lamp for year, all expenses added	$36.05
Adding 4½ per cent interest and 5 per cent depreciation	51.92
Actual cost per arc lamp for current and maintenance	19.53
Actual cost per arc lamp for labor, globes, electrodes	2.21
Actual cost per arc lamp for globes (only)	0.50
Actual cost per arc lamp for electrodes (only)	1.14
Actual cost per arc lamp for labor (only)	0.76

OUTPUT

Total output for the year 1912 in kilowatt-hours	503,260
Arc lamps consumed	380,890
White Way consumed	122,370

FUEL

Total coal consumed, tons	1,393.80
Total coal to generate steam, tons	1,267 89
Total coal to bank fires and for heating boilers, tons	125.91
Natural gas used as fuel, cu.ft.	11,183,632

WATER

Total amount during year, lb.	23,126,875
Total amount used in boilers, lb.	21,694,500

COST PER KILOWATT-HOUR

Coal, only	$0.00726
Natural gas	0.00857
Labor and engine supplies	0.01043
Coal, labor and engine supplies	0.01769

SUMMARY STATION CHARTS

Coal per kilowatt-hour, lb	6 6
Water per kilowatt-hour, lb.	43 1
Water evaporated per pound of coal, lb.	6 5
Natural gas per kilowatt-hour, cu.ft.	85.73
Natural gas equivalent to 1 lb. coal, cu.ft.	13
Number hours arc lamps were off	1066
Hours plant was shut down	738 5
Hours machinery was in operation	3113
Hours arc lamps burned	2733
Arm lights on Kan. Ave., White Way burned, hr.	1768
Top lights on Kan. Ave., White Way burned, hr.	3113

In the White Way data it was shown that the operating and maintenance cost per pole for the year was $14.54, or $2.90 per lamp, which may be compared to $63 for the same size of lamp and a system exactly similar at Virginia, Minn., to $21 at Fort Wayne, Ind., for poles carrying 240 watts less, and to $50.02, which was the Edison company's charge per pole to furnish current and maintain the service.

As a matter of interest, it was stated that in treating the feed water to reduce scale in the boiler, the plant had been using a boiler compound that cost practically 7.2c. per thousand gallons of water treated. On Nov. 6 a change was made to graphite, at a cost of nine mills per thousand gallons treated. This amounted to a saving of $160 per year, with better results.

The employees were one superintendent, two engineers, three firemen, one lamp trimmer and one chief lineman, making a total of eight. The operating expenses for the plant for the year were as follows:

Miscellaneous expense	$1,404.81
Engine supplies	1,098.33
Series tungsten lamps	96 46
Line material	368.13
Extra labor	689 75
Salaries	6,787 65
Fuel, coal and natural gas	3,804 95
Maintenance of horse and wagon	117 78
Freight and drayage	159.73
Electrodes	485 00
Arc globes	152.75
Insurance	74.35
Mercury bulbs	1,053.59
Total	$16,293 26
Balance	106 74
Operating budget for year	$16,400.00

Other data showing the disbursements for the special lighting, reconstruction, arc-lamp data, giving the number of electrodes and globes used and the hours to trim, were given, also some recommendations for improvement, but, due to lack of space, these data must be omitted. Monthly figures on the load, coal, gas and water were also made up in tabular form from the station log charts, but as the totals for the year have been already given these tables have also been omitted.

Test of a Lentz Engine

Below is given results of a test on a 12x18-in. Lentz poppet-valve engine at Alliance, Neb. This engine is direct connected to a 100-kv.-a. Fort Wayne 2300-volt, 60-cycle, three-phase alternator, and with a 250-kv.-a. unit is installed in the municipal lighting plant. The contractor guaranteed this unit to deliver a kilowatt-hour at the switchboard with not more than 36 lb. of dry steam of 140 lb. pressure; exhaust to be free to the atmosphere and the unit to be fully loaded with a power factor of unity.

In conducting the test it was decided that it would be of more advantage to have the conditions the same as would occur in everyday operation, and by corrective factors check the results with the guarantee.

The water was first metered and then weighed on a tested scale. The boilers were fed by injectors with the overflow draining back to the water tank into which the feed water was dumped after being weighed. All boiler openings were blanked, save the main steam line, the drips of which were run to the water tank. Readings were taken every ten minutes, the load being held practically constant by water rheostats, which formed part of the load.

DATA OF TEST

Location	Alliance, Neb.
Date (six months after installation)	June 29, 1912
Duration of test	10:30 a.m. to 3:30 p.m.
Engine size, in.	12 × 18
Generator rating, kv.-a.	100
Generator output, kw.-hr.	446.5
Ammeter reading	256.6
Voltmeter reading	114.1
Apparent output, kv.-a.	101
Power factor, per cent	88
Exciter output, kw.-hr.	40
Total output, kw.-hr.	486.5
Steam pressure, lb. gage	149.6
Back pressure, lb. gage	5
Per cent. moisture	1.5
Mean effective pressure	67.5
Indicated horsepower	156
Generator load factor, per cent.	89
Total water, lb.	19,520
Water per hour, lb.	3,904
Kilowatts per hour of generator	89.3
Kilowatts per hour, including exciter	97.3
Steam per kw.-hr.	40.1
Steam per i.hp.-hr.	25
Correction for moisture, per cent	—1.5
Correction for 5-lb. back pressure, per cent	—11.0
Correction for steam pressure of 150 lb. instead of 140 lb., per cent.	+1.5
Correction for power factor, per cent	—2.2
Steam per kw.-hr. with steam pressure of 140 lb., zero back pressure and 100 per cent. power factor, lb.	34.9
Steam per i.hp.-hr. under above conditions, lb.	22.25

This test was run by the light and water commissioner, who is a technical man with several years of experience. He had for his assistants the chief engineer of the plant, a representative of the engine builders and two seniors from the engineering department of the University of Nebraska. All instruments and scales were tested and it may be assumed with safety that the results are accurate.

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International Engineering Congress

A committee on management of the International Engineering Congress, which will be held in connection with the Panama-Pacific International Exposition at San Francisco in 1915, has been appointed, consisting of the presidents and secretaries of the five national engineering societies under the auspices of which the congress is to be conducted, together with 18 members resident in San Francisco.

The committee has selected as its chairman Prof. W. F. Durand, of the American Society of Mechanical Engineers, and as its secretary-treasurer W. A. Cattell, of the American Society of Civil Engineers. The executive offices will be in the Foxcroft Building, 68 Post St., San Francisco.

Chairman Durand has selected members for the papers, finance, publicity and local affairs committees as follows: Papers committee, A. M. Hunt, American Institute of Electrical Engineers, chairman; finance committee, W. G. Dodd, Society of Naval Architects and Marine Engineers, chairman; publicity committee, W. A. Cattell, chairman, and local affairs committee, E. A. Benjamin, American Institute of Mining Engineers, chairman.

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Engineers Wanted by N. Y. Civil Service Commission

Open competitive examinations will be held by the New York State Civil Service Commission for these positions:

Assistant Steam Engineer, Monroe County Service. Open to legal residents of Monroe County only. Candidates must have had two years' experience as machinist, boilermaker, steam fitter, oiler, fireman or engineer. Subjects of examination and relative weights: Practical questions on the operation and repair of steam boilers and pumps, 4; experience, education and personal qualifications, 6. Two vacancies exist at the Iola Sanatorium, West Brighton, at $75 per month or $60 per month with maintenance.

Junior Railway Engineer, Public Service Commission, First District. Salary $901 to $1200 per annum. The duties are to inspect the power houses and equipment of subway, elevated and street railways, and of electric companies in New York City. Candidates must have had at least three years' training in a technical school of recognized standing and not less than one year's experience in electric railroad or electric lighting work or in the manufacturing or installation of electrical or mechanical apparatus. Subjects of examination and relative weights: Theoretical and practical questions relating to the construction and operation of powerhouse and railway equipment, measurements, standards and other pertinent subjects, 5; experience and personal qualifications, 3; education, 2. Open to non-residents as above. No sample questions.

All applications must be in the commission's hands on or before June 6. Blanks may be had at the several cities offices of the commission.

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Trebling Its Plant Capacity

Plans have been prepared by the Pittsburgh Rys. Co., Pittsburgh, Penn., for trebling the capacity of its plant on Brunots Island, increasing the capacity from 25,000 kw. to 85,000. Twenty Stirling boilers of 822 hp. each have been ordered. The Westinghouse Co. will supply four 15,000-kw. turbo-generator sets. The condensers and pumps will be furnished by the Worthington Pump Company.

The boilers are to be placed in four batteries of five boilers each. A 14x180-ft. stack will be furnished for each battery.

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I. E. S. Preparing for Annual Convention

At a meeting of the convention committee of the Illuminating Engineering Society, held in Pittsburgh, May 16, it was decided to hold the next annual convention in that city during the week beginning Sept. 22.

The committee consists of G. A. Littlefield, New York Edison Co., Chairman; P. S. Millar, Electrical Testing Laboratories, president; H. S. Evans, Macbeth Evans Glass Co.; W. A. Donkin, Duquesne Light Co., Pittsburgh; W. D. Macfarlan Moore, General Electric Co., Harrison, N. J.; M. C. Rypinski, Westinghouse Electric & Manufacturing Co., New York; C. J. Mundo, General Electric Co., Pittsburgh; J. C. McQuiston, Westinghouse Electric & Manufacturing Co., Pittsburgh; W. J. Serrill, United Gas Improvement Co., Philadelphia; S. B. Stewart, Philadelphia, Co., Pittsburgh, T. J. Pace, Westinghouse Electric & Manufacturing Co., Pittsburgh; and Prof. H. S. Hower, Carnegie Technical Schools, chairman of the local section of the society.

W. A. Donkin was selected as chairman of the local committee on arrangements and J. C. McQuiston was appointed chairman of the publicity committee.

It is expected that several hundred engineers from all parts of the country interested in lighting will be present. The program, the details of which have not been completed, will consist, in addition to the technical sessions, of a reception and dance, several excursion trips and visits to various industries in Pittsburgh.

New Jersey's N. A. S. E. Convention

Despite the continuous rain for the first two days of the New Jersey State convention of the National Association of Stationary Engineers, held in Palace Hall, Newark, Thursday, May 22 to Sunday the twenty-fifth, the exhibit and convention were most successful. Palace Hall is ideal for exhibits. Frank Martin, who has seen more halls and auditoriums than most of us, said it was the finest exhibit hall he had ever seen at any convention. Mayor Haussling opened the convention.

On Friday and Saturday afternoons meetings of the officers and delegates were held preparatory to the Sunday session in the meeting rooms of Newark No. 3 Association.

State President Martin J. Hickey, of Jersey City Association No. 1, called the convention to order at 11:25 a.m., and received the reports of the various committees. The report of A. L. Case, chairman of the license-law committee, was accompanied by a presentation to the president of the pen used by Governor Fielder in signing the license law. This pen will be framed with the state charter.

The eulogy address on the deceased members was made by John J. Calahan, of Jersey City. Mrs. Parisan, state deputy of the Ladies Auxiliary, told of the achievements of that body.

Engineers of ten years' experience and who have been members of the N. A. S. E. for that length of time, are entitled to a pension should they become indigent. The present benefits amount to $15 per month, and it is hoped to increase this amount or reduce the time period for qualification.

National Vice-President James R. Coe reported that in 18 states there were 16 state associations, a total of 220 local associations representing 14,346 members.

SOME OF THE OFFICERS AND DELEGATES

THOSE WHO ENJOYED THE BANQUET

The officers elected for the ensuing year are as follows: President, John T. Jenkinson, Paterson No. 2; vice-president, Charles W. Summers, Hoboken No. 1; treasurer, Thomas J. Brown, Newark No. 3, reëlected; secretary, John J. Ready, Jersey City No. 1; conductor, James S. Heath, Elizabeth No. 14; doorkeeper, Thomas McNamara, Paterson No. 2. The president was directed to recommend the retiring president, Martin J. Hickey, to the national officers for the office of state deputy. Past National President W. J. Reynolds installed the new officers.

The banquet in the Continental Hotel, Sunday evening, closed the convention. Toastmaster William J. Reynolds introduced the following speakers: J. H. Donnelly, president, Newark Common Council, whose speech was responded to by National Vice-President Coe. W. R. Sickle, counselor for the license-law committee, pointed out the necessity of getting the legislators now in special session to make the appropriation required to put the license law into immediate action.

C. H. Bromley, of Newark No. 3, and associate editor of "Power," told of the educational work in New Jersey. Stress was laid on the necessity for revising the slides and notes put out by the national educational committee in order to accomplish the best results in practical power-plant education.

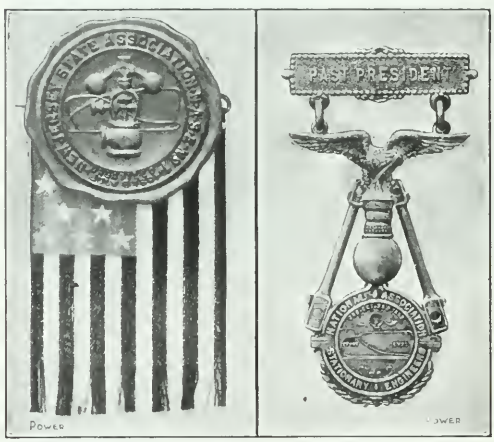
F. R. Low, editor of "Power," reviewed the important feature of recent engineering progress, citing actual cases showing the necessity for greater qualifications of men to handle modern power plants. Past State President Martin Hickey told of the progress made in fraternal work during the past year.

Past-Presidents N. J. State Association

Exhibit Hall, New Jersey N. A. S. E. Convention

Entertainment under the direction of Frank Martin was furnished by Herbert Self, Jim Devins, Billy Murray, Jack Armour, Joe McKenna and The Dixie Four, a female quartet of exceptional ability.

The exhibitors were the Albany Lubricating Co., Armstrong Cork Co., Ashton Valve Co., American Oil & Supply Co., Babcock & Wilcox Co., Boig & Hill, Buhne Metal Packing Co., Clipper Belt Lacer Co., Crandall Packing Co., Coppus Engineering & Equipment Co., Cooney Contracting Co., Clement Restlen Co., Cinch Belt Co., Crane & Milligan, C. T. Coe & Co., Crane Co., Couse & Bolton, C. E. Squires Co., Durabla Manufacturing Co., Dearborn Chemical Co., David C. Seymour, Diamond Power Specialty Co., Economy Fuse Manufacturing Co., F. W. Webb Manufacturing Co., Fairbanks Co., Greene, Tweed & Co., Garlock Packing Co., Griscom-Russell Co., Greenpoint Fire Brick Co., Harrison Safety Boiler Works, Home Rubber Co., H. W. Johns-Manville Co., Hill-McKanna Co., H. B. Underwood & Co., Hazard Manufacturing Co., Homestead Valve Manufacturing Co., Hewes & Phillips Iron Works, J. R. Nelson, Jenkins Bros., Jackson Awning Co., John A. Roebling Sons Co., J. H. Banks Co., Keystone Lubricating Co., Lunkenheimer Co., Ludlow & Squiers, Lagonda Manufacturing Co., Manning, Maxwell & Moore, M. T. Davidson Co., McLeod & Henry Co., Mutual Supply Co., New York Belting & Packing Co., "National Engineer," Norbin Oil & Supply Co., National Oil & Supply Co., Otis Elevator Co., "Practical Engineer,"



Peerless Rubber Manufacturing Co., Philadelphia Manufacturing Co., Pitts & Kitts Co., "Power," Precision Instrument Co., Philadelphia Grease Co., R. & J. Dick Co., Ross & Taggard, S. F. Bowser & Co., Strong, Carlisle & Hammond Co., Standard Oil Co., Standard Regulator Co., the A. & F. Brown Co., the United States Graphite Co., the Texas Co., V. D. Anderson Co., W. B. McVicker Co., William Powell Co., United Coal Savers' Association, United Metal Hose Co., Dick Belt Co., Quaker City Rubber Co., Chas. J. Hoffman, Engineers Blue Club of New Jersey, Ladies Auxiliary No. 2.

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Pittsburgh's New Boiler Plant

The Crucible Steel Co. of America is building a model boiler plant at its works at Forty-first St. and the Allegheny Valley R.R., in the Lawrenceville district of Pittsburgh. The building alone will cost $95,000. It will cover a space of 252x45 ft. and will be 45 ft. high.

Fourteen 600-hp. boilers will be placed in the structure in seven batteries. Each battery will have a separate stack. By the use of smokeless stokers of the chain type the plant will be almost without smoke, thus enabling the company to comply with the laws of the city and state and add to the benefits to be conferred to the district.

SOCIETY NOTES

A party of British engineers arrived in New York on May 26. These visiting engineers are members of the institution of Automobile Engineers of England, and will attend the semiannual technical sessions of the Society of Automobile Engineers, under the auspices of which they will also make an inspection tour of automobile-manufacturing plants throughout the country.

The semiannual meeting of the Society of Automobile Engineers will be held on board a steamer cruising the Great Lakes. Four professional sessions will be held on June 5, 6 and 7, the party leaving Detroit on the "City of Detroit III," chartered exclusively by the society, on the afternoon of June 4. The technical discussion will be in part in connection with reports of the standards committee divisions on irons and steels, ball and roller bearings, motor-truck elements, starting, lighting and ignition systems, broaching tools, pneumatic-tire rims, fuel, motor testing and nomenclature. Several papers are to be presented by British engineers.

Elaborate arrangements for the edification and entertainment of the visiting European engineers have been made in New York, Pittsburgh, Indianapolis, Detroit, Cleveland, Buffalo, Providence, Bridgeport, New Haven and Hartford.

The summer meeting of the American Society of Heating and Ventilating Engineers will be held at Buffalo, N. Y., on July 17, 18 and 19. The headquarters will be at the Statler Hotel in that city.

The last meeting of the season of the Massachusetts Chapter of the American Society of Heating and Ventilating Engineers was held May 13, at Boston. The subject was humidity, and was discussed by W. C. Elliott, Stuart Cramer Co.; W. W. MacLean, Museum of Fine Arts; Charles F. Eveleth, School House Commission, Boston; Frank T. Chapman, of the New York Chapter. Mr. Elliott said that since the installation of the humidifying system in the Cheney Silk Mills there had been a wonderful freedom from all kinds of contageous diseases in the plant. Mr. MacLean explained that quite often they have loans of valuable furniture in the museum and such things would not be loaned to them unless they had special arrangements for placing the exhibit in an atmosphere where it would not fall to pieces. They also have on exhibition rare and costly paintings and Chinese lacquer work, which require uniform conditions. President Cooper read a communication which is of general interest. A commission has been appointed in New York by Governor Sulzer to make a special study of the heating and ventilating of school houses, which is made possible under a recent contribution of $50,000 by Mrs. Elizabeth Millbank Anderson. The committee to be appointed by Governor Sulzer will include Prof. C. E. A. Winslow, College of the City of New York; Prof. F. S. Lee, College of Physicians and Surgeons; James Alexander Miller, medical expert, Bellevue Hospital; Prof. E. B. Phelps, Massachusetts Institute of Technology; Prof. Edward L. Thorndike, Columbia University, and Dwight D. Kimball, engineer of New York City.

The subject of a midsummer meeting was taken up and an enjoyable outing is anticipated, which is left to the call of the president. The chapter meetings were adjourned until Oct. 14.

PERSONALS

N. T. Fortun has been elected manager of the Lyle (Minn.) electric-light plant, succeeding N. G. Fischer.

C. T. Wheat has succeeded William McKinley as superintendent of the Madison County Light & Power Co., Carlinville, Ill.

Charles Schaefer has succeeded W. H. Hartman as superintendent of the municipal electric-light and power plant at Opelika, Ala.

E. Cutting has been appointed superintendent of the municipal electric-lighting plant at Riverside, Calif., succeeding F. A. Worthley, resigned.

R. T. Morris, municipal electrician of South Vancouver, B. C., has resigned to associate himself with G. M. Gest, conduit engineer and contractor.

OBITUARY

JAMES WALKER

On May 8, James Walker, the founder and chairman of James Walker & Co., Ltd., "Lion" Works, London, England, died at his residence, Leytonstone. Mr. Walker had a wide acquaintance in the engineering field on both sides of the Atlantic, and was highly esteemed. He was 73 years old.

Mr. Walker's death will not occasion any change in the organization of which he was the head, as the management will be conducted, as heretofore, under the direction of George H. Cook, the managing director.

POWER

Vol. 37 JUNE 10, 1913 No. 23

Different Yesterday, Today and Forever

Consider the calendar. It changes every day. So does human knowledge. The solemn science of centuries ago is the rankest superstition of today. The best established scientific (so-called) fact of today may explode with a loud report tomorrow.

Don't be too positive. Remember, lightning was one of the greatest terrors of mankind till Benjamin Franklin took a flier in kites. Now one man presses a button to start a world's fair. Man has done a good deal but he doesn't know it all. Vessels have crossed the Atlantic a good many million times since Columbus made his trip, but a little while ago the sea swallowed at one gulp the biggest ship ever made.

Human knowledge is a mighty curious thing. It is continually taking on something new at one end but, while doing so, is letting go something old at the other.

Nothing is too new to be impossible or so old as to be certain. Don't refuse the new just because it is new nor cling to the old just because it is old.

A closed house gets mighty musty, but a house without a roof soon goes to decay. Keep your mind open but keep something in it.

Open the doors and the windows once in a while and give the sunlight a chance, but don't tear down the walls for the sake of ventilation and so let the wind blow out your furniture.

Don't run ahead, but don't fall behind. Remember the calendar and try to keep up to date.

[*Hugh Molleson Foster, New York.*]

Testing Small Steam Turbines

By R. C. Allen

SYNOPSIS—How one manufacturer of small steam-turbines tests them and a description of the apparatus used, showing that the laboratory is fully equipped for doing the work. All turbines are fully tested before shipment, for governor adjustment and other details which can affect the satisfactory operation of the unit when installed in the power plant.

The increasing activities of power-plant engineers in investigating general station economics, and the tendency toward the adoption of steam turbine-driven auxiliaries in power plants, has led to investigations of the actual efficiencies guaranteed by steam-turbine manufacturers, as well as the institution of exacting tests to determine the merits of a particular machine before installation. The testing department, therefore, of a representative works must be more than the mere testing room, sufficient for the requirements of a few years ago; it must be a fully equipped laboratory as well, comprising all the necessary apparatus for testing generators, blowers, and for experimental work generally, in addition to regular performance tests of the turbines themselves.

One manufacturer of small turbines, the Terry Steam Turbine Co., has instituted a test department representative in every way, both as regards equipment and general organization. A general view is shown in Fig. 1. The following description of apparatus and general methods employed will undoubtedly prove interesting in general, as well as serve to indicate the thoroughness with which the characteristics of the machines manufactured are investigated before shipment.

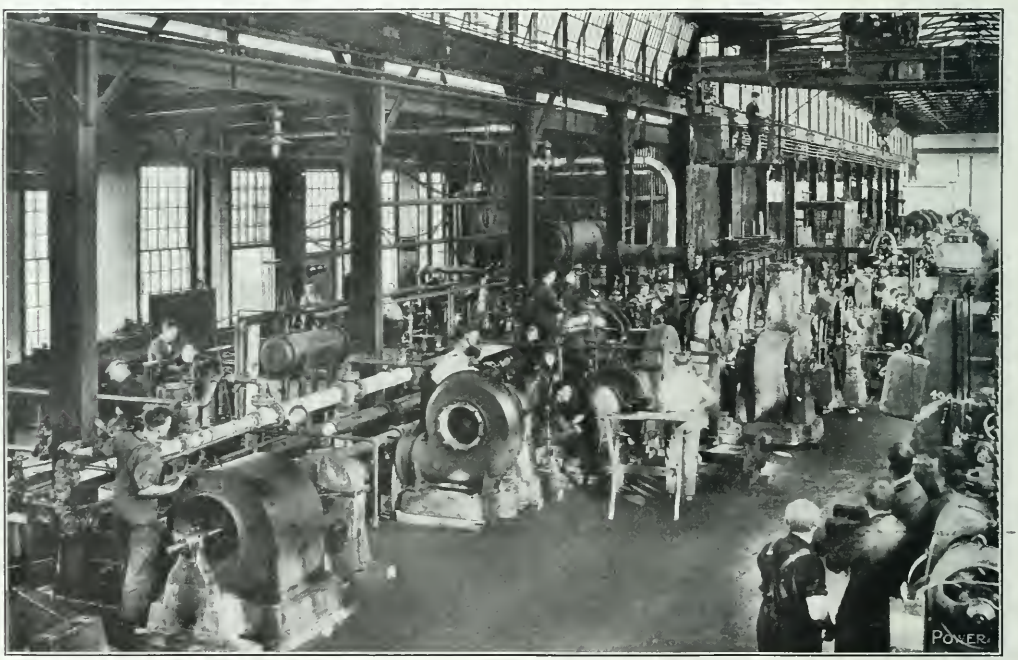

Fig. 1. General View of the Testing Department

Boiler Equipment

The boiler equipment consists of three vertical 500-hp. Manning boilers, a combined capacity sufficient for testing all machines at full load, or at loads sufficiently great that precise full-load conditions may be interpolated. The boilers are hand fired, and worked with either natural or induced draft, a good grade of semibituminous coal being used.

The boilers are connected to a common header, which is connected to the extra-heavy steel main-test line, placed about 4 ft. from the floor and fitted with numerous outlets, each provided with a throttle valve. The boilers, fittings and valves are designed for a normal working pressure of 200 lb.; the usual pressure maintained is about 150 lb. The higher pressures are used for testing turbines built under specifications requiring same. All power-plant auxiliaries exhaust into an open heater, a feed temperature of from 185 to 212 deg. being obtained.

Directly beneath the main steam-test line, which runs lengthwise through the center of the test floor, are two main exhaust lines, one being the plant-auxiliary exhaust line leading to a heater at practically atmospheric pres-

sure. The other line leads to the main condenser, and is used when water rates are required on condensing or noncondensing machines, or when any general tests are required on condensing machines. For each test connection in the high-pressure steam line, there is a corresponding opening in both the condensing and noncondensing exhaust lines, a simple form of connecting pipe and valve making it possible to couple a machine to either exhaust line as desired.

The main condenser is of the surface type, and of ample capacity to handle condensing machines up to 750 hp. capacity with a vacuum of 28 in. referred to 30-in. barometer.

A dry-air pump of unusual proportions takes care of the air leaks that are impossible to eliminate in temporary test piping.

Constant hotwell-level control is obtained by the usual method of a float-regulated steam valve, controlling a duplex pump, which discharges into a chute, which may be alternately directed into two tanks, mounted on separate standard weighing scales, the tanks being also fitted with the necessary outlet valves leading to drains. As the method of weighing surface-condenser discharge is generally considered the most satisfactory and indisputable means of determining the total steam consumption of any steam-driven prime mover, the greatest care is taken to maintain this equipment in the best possible condition, particularly with regard to water leaks around tube glands, as well as air leaks into the system.

Main Testing Apparatus

A complete secondary testing equipment is installed to handle machines of 50 hp., and below, running condensing or noncondensing.

Condensing Apparatus

The main Worthington condensing equipment is standard apparatus, which also includes a cooling tower, the circulating pump of which is driven by a 40-hp. Terry turbine; the fans, however, are driven by a 15-hp. motor, supplied with current from the factory mains. The testing apparatus for large turbines is shown in Fig. 2.

The secondary condensing equipment for smaller machines includes a small C. H. Wheeler surface condenser, hand-controlled hotwell pump, and separate dry-air pump, separate measuring tanks and scales being furnished, all similar to the main equipment, but on a smaller scale. The equipment for testing small turbines is shown in Figs. 3 and 4. Cooling water is bypassed from the main condenser circulating-pump discharge, the outgoing water leading to the cooling tower.

All steam gages used are periodically calibrated by a dead-weight gage tester. Important readings, such as nozzle-inlet pressures, are frequently taken by a number of gages connected to various points in the steam belt, thus eliminating possible chances of error in the instruments, as well as possible effect of local disturbances in the steam belt itself at points of measurement.

All electrical instruments used are also checked at intervals to insure their reliability.

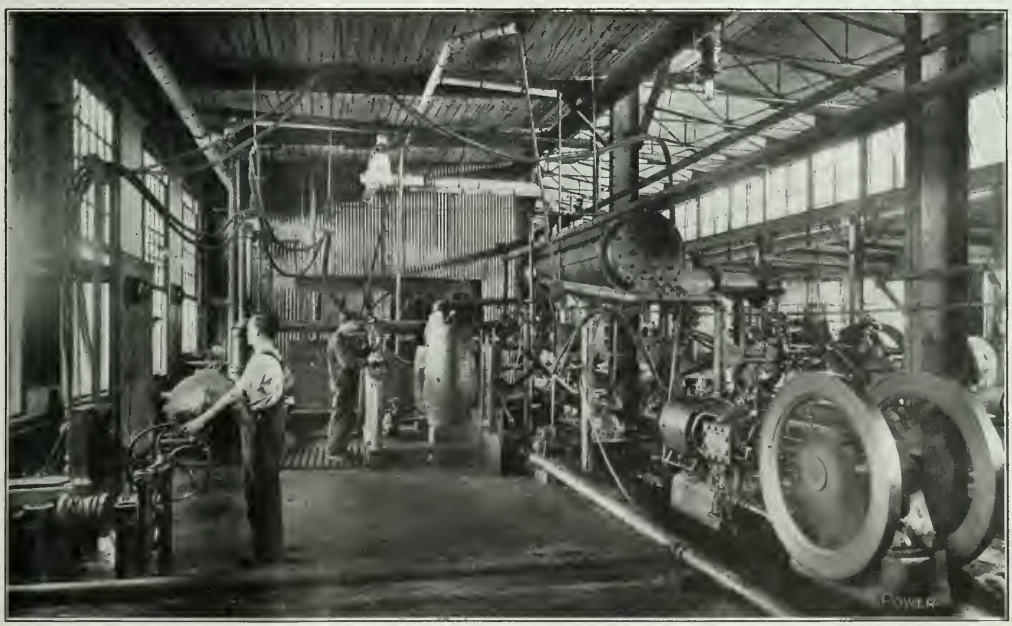

Fig. 2. Testing Department for Large Turbines

Testing

Final testing of all turbines before shipment consists of connecting the turbine to the proper steam and exhaust lines, adjusting the governor to no-load speed, adjusting the shaft glands, safety valve and the emergency governor, also the thrust clearance and proper location of the wheel with reference to the stationary element.

The turbine is then run for several hours after the final adjustments are made, the exact time depending on the judgment of the representative from the engineering department who finally releases the machine. Any indications of bearing or governor troubles, however, are sufficient to prolong the test, until satisfactory operation is obtained.

By this method, the machines are finally inspected by a representative of the engineering department who is a disinterested party in their manufacture, and who is in no way connected with their erection or testing, but is called upon in each particular case to act in the capacity of a customer inspecting his purchase.

The majority of test work consists of running complete tests for capacity and steam consumption, either for visiting engineers representing the purchaser, or to check up the characteristics of any particular turbine on account of the possible lack of data on its operating conditions, which may be unusual.

These turbines are connected to the main condenser (or the secondary condenser if below 50 hp.), exhaust line being fitted with mercury column and vacuum gage if the turbine is to run condensing and mercury manometer and compound gage if the machine is to run noncondensing a steam gage is fitted in the main steam line, and usually two or more gages between the governor valve and the nozzle inlets, viz., in the steam belt or steam "ring." Steam temperatures and calorimeter measurements are taken in the steam line immediately before the governor valve, the "Carpenter" type of throttling calorimeter being used.

The load is taken by either a prony brake or water brake, Fig. 5, according to the precise operating conditions. In the majority of cases one of the water brakes or familiar Webb dynamometer is used, consisting of a series of smooth disks (alternately revolving and stationary) inclosed in a casing mounted on ball-bearing trunnions, water being fed into the sides of the casing near the shaft, and discharged at the bottom of the same, Fig. 7. The main bearings are hung from the casing in order to include the bearing friction in the turning moment as recorded. The brake arm being mounted on the casing, the torque is measured by standard scales in the usual manner.

Several water brakes are used, each covering a definite range of speed and horsepower, the capacities overlapping sufficiently to have a brake available for every conceivable operating condition.

The test-floor equipment also includes similar prony brakes for running tests on turbines at speeds below the satisfactory operating range of the water brakes.

The speed is read by a tachometer belted to a brake shaft, as well as by either a portable hand tachometer or counter applied directly to the end of the shaft. The usual method of procedure is to first adjust the turbine governor to a speed, say, 10 to 20 per cent. higher than the normal speed. The required steam and exhaust conditions are then obtained and maintained constant

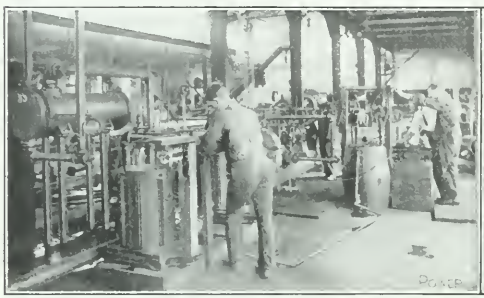

Fig. 3. Testing Small Turbines

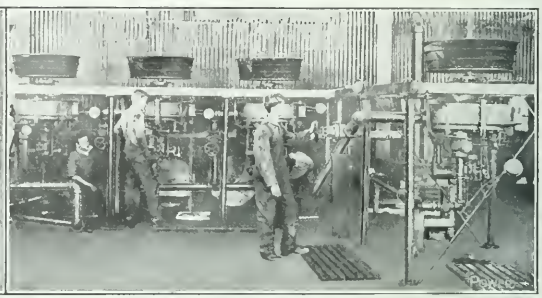

Fig. 4. Testing Vertical Units

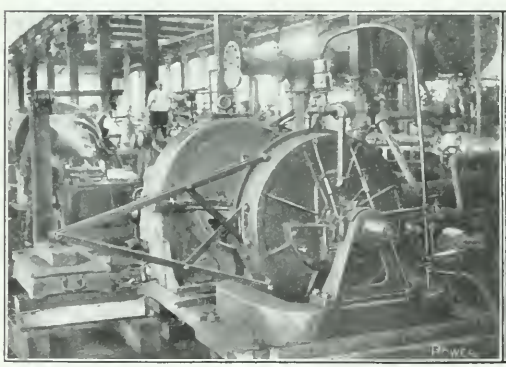

Fig. 5. Near View of Water Brake

Fig. 6. Testing Blower Unit

throughout the test by adjusting the throttle and exhaust valves, the load meanwhile being built up on the brake. When steam conditions are reached, the load on the brake is varied by throttling the inlet and discharge water until the desired speed is reached and maintained.

This method gives the least number of variables as well as permitting the absolutely constant steam flow itself, particularly with regard to the compounding of direct-current generators; also, the final heat-run temperatures.

In the case of blower units, the tests are usually in accordance with the type of service for which the blower is designed. Gas blowers are either tested by the cone method, taking pitot-tube velocity readings at the end of a

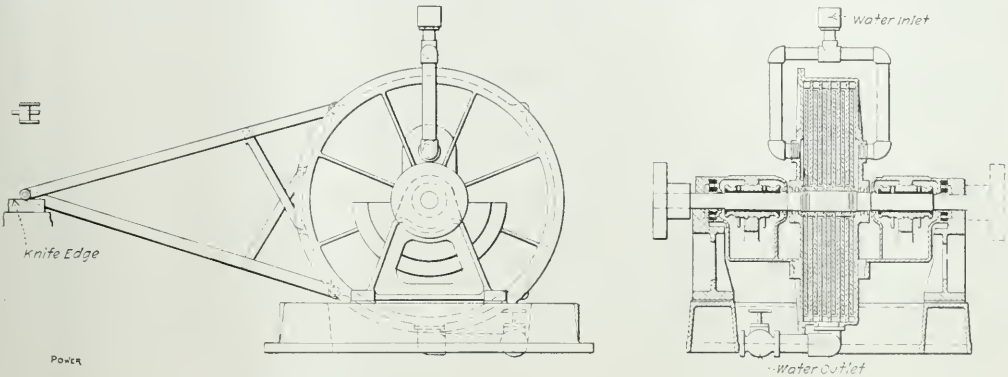

FIG. 7. DIAGRAMMATIC AND SECTIONAL VIEWS OF WATER BRAKE

through nozzles necessary for water-rate tests, which would not be the case if it was attempted to operate the machine on its own governor.

Steam readings, water and brake readings are taken for a reasonable period, say, from 30 to 60 min., after which time the steam pressure is lowered by hand, thus obtaining partial load conditions, and another test made.

Three or four points are thus taken which enable the characteristic curves of capacity, total steam, and water rate to be plotted.

From the results of a great number of tests, the total steam passed by standard designs of nozzles has been carefully checked with Napiers' simple formula:

$$W = \frac{P \cdot A}{70}$$

where

W = Pounds of steam per second passed by nozzles;
P = Absolute inlet pressure in pounds per sq.in.:
A = Total area of orifice in sq.in.

It was shown that it is possible to modify the constant 70 so as to bring the total water rate for particular designs of nozzles as calculated by this method within the limits of accuracy obtainable by actual measurement.

This method has been repeatedly verified by official tests, and has been found so reliable that it is employed in a great number of tests, thereby reducing the time required to conduct a test to a minimum.

In the majority of cases, generating sets are tested up to full load, water rheostats being used. The largest resistance consists of a series of alternate stationary and adjustable plates immersed in a salt-water bath, the adjustable plates being raised or lowered by a windlass adjacent to the test switchboard, it being possible to absorb direct-current loads up to about 3000 amperes.

With each generating set, complete records are made with reference to governor characteristics, steam-ring pressures at various loads (from which water rates may be calculated) as well as the characteristics of the generator

tapered cone fitted to blower discharge, shown in Fig. 6, or by taking pitot-tube readings in a duct fitted to the blower outlet, the standard "Taylor" tube used for these latter tests.

For obtaining blower efficiency the turbine is first

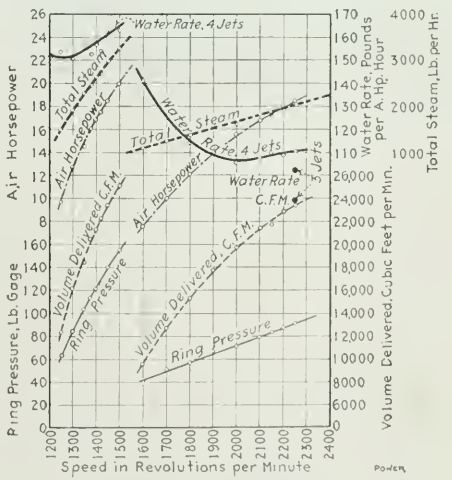

FIG. 8. TEST CURVES

calibrated by running brake tests at various ring pressures as well as at various speeds and plotting these results in curve form. During the air tests, the speed and ring pressure being noted, for any particular delivery, the brake horsepower delivered may be interpolated directly from the calibration curves, and as the air horsepower can be calculated directly from the pressure and capacity readings, the blower efficiency may be directly determined.

Blowers or fans designed for discharge into a closed compartment are tested out by actually discharging them

into a suitable air-tight room, air readings for capacity being taken in the blower inlet, which is fitted with a tube of sufficient length to obtain parallel steam lines.

All test log sheets are in the form of loose leaves for loose-leaf notebook, which proves a convenient means of preserving data, either in shop tests or in tests made in outside power plants.

The final test report is made out on printed forms signed by the inspecting engineer, it being possible to easily copy by blueprinting without danger of error.

A set of test curves is shown in Fig. 8, illustrating methods used in graphically recording tests.

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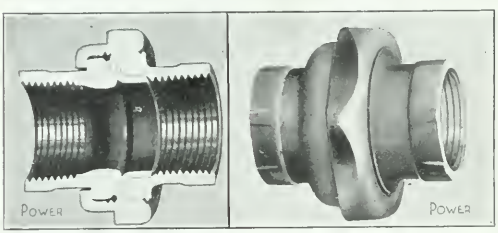
Mark Cold-Drawn Steel Union

This union is made seamless from cold-drawn, flat-strip steel. Each union is treated by a sherardizing process to render it immune from rust and corrosion. This process consists of heating the parts with zinc dust in a retort, which causes the zinc to penetrate a short way into the metal, and also leave an exterior coating. As the threads are cut before the treatment, they are also protected against corrosion without altering their sharpness and fit.

The Mark union, which is manufactured by the Mark



Sectional and Exterior View of the Mark Union

Manufacturing Co., Chicago, Ill., consists of three main parts, male and female ends, which are joined by a coupling nut. A brass-ring seat fits between the coupling ends, as shown. The union is threaded to Briggs standard for pipe threads, and carries the same taper as the pipe. The expansion and contraction of the union under heat or cold is practically the same as the pipe.

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Boiler-Efficiency Chart

By John C. Parker

The chart herewith shown will be useful in connection with tests for determining the efficiencies of boilers at all ratings between banked fires and full capacity, and for calculating the results of individual boiler tests.

From the ordinary boiler-test data (gage pressure, feed-water temperature, actual water and fuel per hour and heat value of fuel) the equivalent evaporation per hour and per pound of fuel, horsepower and efficiency can be read direct from the chart with sufficient accuracy for ordinary use. The chart is especially valuable as a check on the calculations of boiler tests and serves to show up improbable results.

The moisture in the steam should be deducted from the quantity of water, or in case of superheat an equivalent allowance should be made in the quantity or temperature of the feed water. When the quantities are beyond the range of the chart, take one-half, one-quarter or one-tenth as the case demands, and for horsepower multiply by the same factor.

The fuel quantity can be in terms of fuel as fired, dry fuel or combustible. The heat value of the fuel must be taken on the same basis. The following problem is worked out with Fig. 1 as a key:

Test data:

Gage pressure, 150 lb. per sq.in.
Feed-water temperature, 62 deg. F.
Actual dry steam per hour, 10,000 lb.
Coal per hour, 1200 lb.
Heat in 1 lb. of coal, 13,863 B.t.u.

The dotted lines and arrows shown on the key indicate a simple method of procedure. Starting at the pressure scale (150 lb.), move horizontally to the equivalent feed-water temperature line (62 deg.), thence vertically down to the actual water evaporated per hour (10,000 lb.), thence horizontally to the water scale at the left and return along the inclined water line to the same ordinate. Here read the equivalent evaporation per hour (12,000 lb.). Move horizontally to the fuel per hour (1200 lb.), thence along the evaporation radial (10 lb.) to the B.t.u. (13,863) and vertically upward to the efficiency scale (70 per cent.).

By reading the 10,000 lb. horizontal water line as 1.0000 and 0.10000 for each thousand pounds above it, the factors of evaporation are found along the inclined

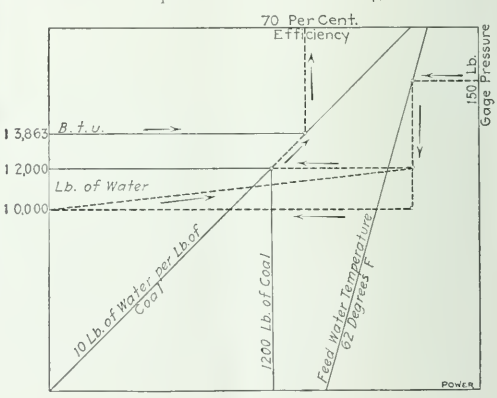


Fig. 1. Key to Chart

equivalent water line which starts from the same point on the water scale. To find a factor, move vertically from the pressure- and feed-temperature intersection to the 10,000-lb. horizontal water line, and that portion of the ordinate between this and the corresponding inclined line represents the decimal part of the factor for those conditions. In the foregoing problem the factor is 1.2000.

The dotted curve is assumed to illustrate the characteristic trend of normal efficiency curves from banked fires to full capacity. Three curves are combined in it: 1. The water curve with uniform increase in combustion; 2. The fuel curve with uniform increase in capacity; 3. The economy curve at all ratings. The complicated operation of normalizing separate fuel, water and efficiency curves and making them agree is thus avoided.

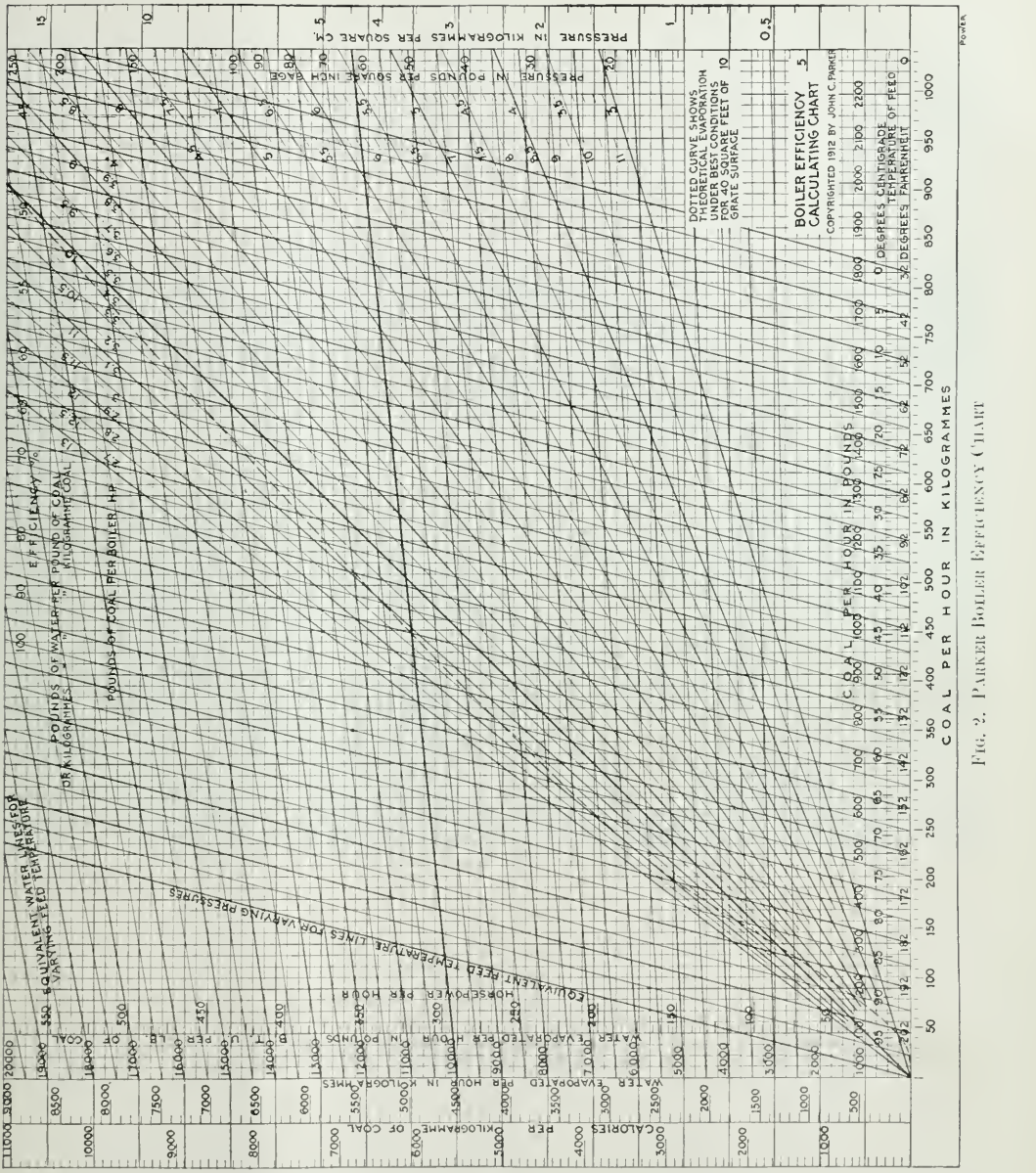

BOILER EFFICIENCY CALCULATING CHART
COPYRIGHTED 1912 BY JOHN C. PARKER
DOTTED CURVE SHOWS THEORETICAL EVAPORATION UNDER BEST CONDITIONS FROM AND AT 212° FAHR. PER SQUARE FOOT OF GRATE SURFACE
COAL PER HOUR IN POUNDS
COAL PER HOUR IN KILOGRAMMES
EFFICIENCY %
POUNDS OF COAL PER BOILER H.P. PER HOUR
POUNDS OF WATER PER POUND OF COAL
OR KILOGRAMMES
EQUIVALENT WATER LINES FOR VARYING FEED TEMPERATURE
EQUIVALENT FEED TEMPERATURE LINES FOR VARYING PRESSURES
HORSEPOWER PER HOUR
EVAPORATED PER HOUR IN POUNDS
EVAPORATED PER HOUR IN KILOGRAMMES
CALORIES PER KILOGRAMME OF COAL
PRESSURE IN POUNDS PER SQUARE INCH GAGE
PRESSURE IN KILOGRAMMES PER SQUARE C.M.
DEGREES CENTIGRADE TEMPERATURE OF FEED
DEGREES FAHRENHEIT

FIG. 2. PARKER BOILER EFFICIENCY CHART

The normal efficiency curve shows the most economical rating and furnishes the necessary data for estimating the variable-load fuel consumption for normal operating conditions. It is also a valuable guide to economical operation from which the proper number of boilers to carry a given load can be ascertained.

The metric scales outside the main chart have nothing to do with its ordinary use. They are added for convenient comparison of foreign boiler-test results with our own. The scales can also be used as conversion tables for Centigrade and Fahrenheit temperatures, also for kilograms and pounds.

The San Joaquin Light & Power Corporation has arranged with the J. G. White Engineering Corporation for the engineering and construction of a 6000-kv.a. hydro-electric plant on the Tule River, near Springville, Calif., for the installation of a 3000-kv.a. generator at San Joaquin power house No. 2, a 3750 kv.a. generator and waterwheel at Kern River Cañon Plant, the installation of a 6250-kw. steam turbine, boilers and auxiliaries and buildings at the Bakersfield steam plant, and the installation of four 666-kv.a transformers.

Vertical-Lift Furnace Doors

SYNOPSIS—The design and operation of vertical-lift furnace doors are described herein. They are desirable on the furnaces of water-tube boilers, owing to the frequency of bursting tubes, as they safeguard the firemen against accident to some extent.

Danger of injury to firemen, due to the blowing open of furnace doors when a tube bursts, as pointed out in a recent editorial, has been reduced by the adoption of vertical-lift or swing type of furnace doors.

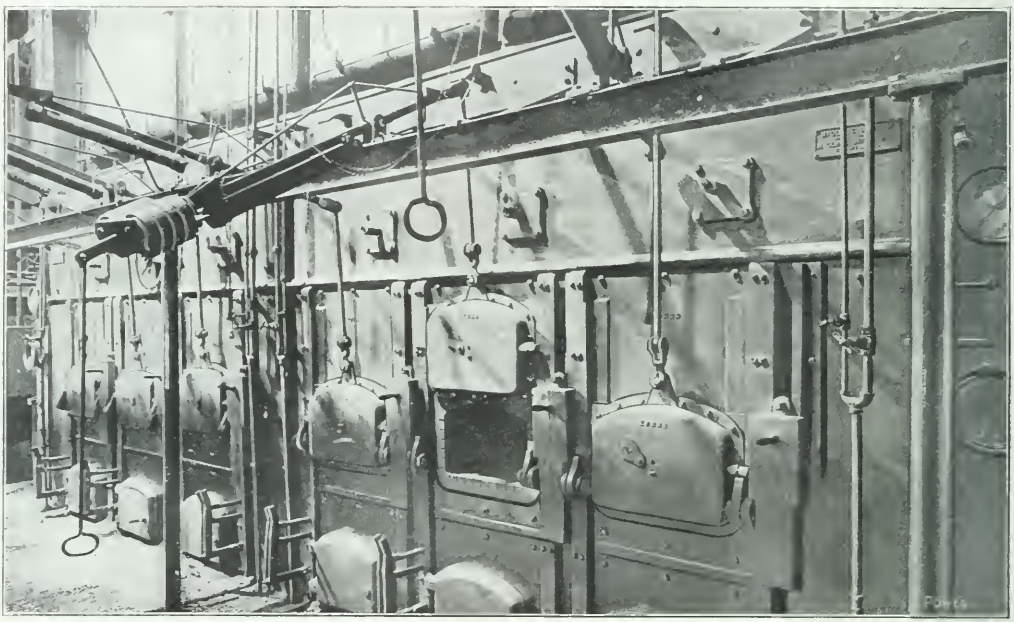


FIG. 1. ARRANGEMENT OF VERTICAL-LIFT DOORS AT HUDSON & MANHATTAN POWER HOUSE

An installation of the vertical-lift type is shown in Fig. 1. This arrangement of furnace doors is in the power plant of the Hudson & Manhattan R.R. Co., Jersey City, N. J., and was installed by the McClave-Brooks Co.

An examination of the illustration shows the operation of the doors. The lift doors run in guide plates attached to the furnace front. An I-beam is supported on iron columns and braced by iron arms attached to the boiler fronts. This I-beam supports the operating lever that is hung on a pin. At the outer end of the lift lever a number of weights, balancing the furnace door, are held in place by clamping plates. A tube, capped at both ends and partly filled with mercury is attached to the under side of the weight arm. On the outer end of the weight arm a hand rod is hooked and extends to within reach of the firemen. At the other end of the weight arm a link connects it with the lift door. The illustration shows the lift doors opened and closed.

To open the door the firemen pulls down on the hand rod. The mercury in the cylinder runs to the lower end of the tube as soon as it has passed a horizontal position.

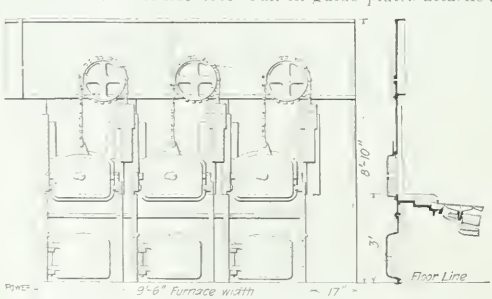


FIG. 2. COUNTER-WEIGHTED VERTICAL-LIFT DOORS

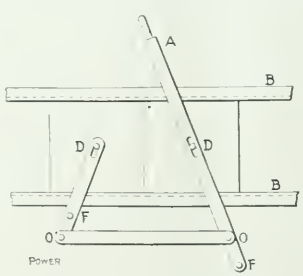


FIG. 3. ENGLISH TYPE OF LOCOMOTIVE FURNACE DOOR

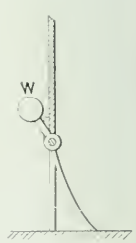


FIG. 4. OLD ENGLISH SWING DOOR

As the counterweight balances the weight of the door and link connection, the additional weight of the mercury keeps the door open until the fireman pushes up on the hand rod and closes the door. The mercury then runs to the opposite end of the cylinder and overbalances the counterweights. The doors are locked shut by the lugs shown on each side of the door, and which lock over the projection on each side of the door.

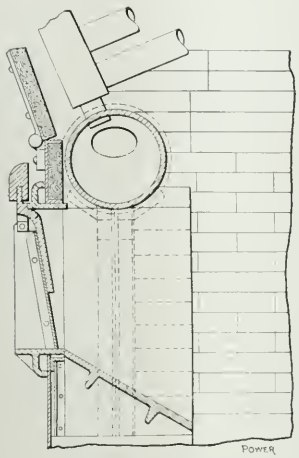


Fig. 5. Furnace Door Opening Inwardly

A similar door, but operated by counterweights is shown in Fig. 2.

An English locomotive type of fire-door is shown in Fig. 3. A handle *A* serves, by a lateral pull, to open the two sliding doors of the furnace. The door when closed is an effective preventer of any flame outburst and, in a modified form, could be applied to the fronts of stationary boilers. An equal movement of the two halves of the door is secured by pivoting at a point, such as *F*. The curvature of the movement at *D* is taken care of by a slot.

A door long used in England is a thin curved iron door, Fig. 4. A weighted lever *W* balances the door, which works stiff enough at any position to resist the pull of the draft, but not so stiff as to prevent its being closed in the event of an explosion in the furnace. As the door can be left slightly open after firing, air can be admitted above the fire, as desired.

Another type of furnace door, made by James Beggs & Co., which cannot blow open if a tube should burst, is illustrated in Fig. 5. It is hinged at the top by a hinge pin which is bolted to the front of the cast-iron fire-door. The hinge pin hangs in bearing bosses on the boiler front. The door is lined with $\frac{3}{16}$-in. steel plate.

A counterweight extends across the furnace door. When the door is tilted inward, the counterweight is moved beyond the center line of gravity and holds the door in a horizontal position out of the way of the firemen. When the door is closed the bottom edge strikes the dead plate before the door reaches a vertical position, leaving the door at an angle of about 82 deg. If a tube bursts the force of the steam and water is exerted against the door tending to close it still tighter.

No door is a protection against furnace explosions when open, while firing, but those shown would be a valuable safeguard.

Elastic Corrugated Piping

Recently a process of manufacturing corrugated tubes has been patented, by which either standard wrought-iron or steel tubes can be corrugated by the Maciejewski process, as it is known. According to the pressure and size required, small- and medium-size tubes are made from ordinary steel tubing; for large diameters, lap-welded and rerolled tubes are used.

The corrugations are made by a method of pressing the material together, a special patented machine being employed. The process shortens the tubes as the corrugations are pressed into them, at equal distances apart, but without decreasing the original inside diameter, and the thickness remains uniform and is the same as in the original tube.

During the process of corrugating, any defects in the material at once become apparent. Interesting examples of corrugated tubes are shown in Fig. 1. They can be made in sizes from $1\frac{3}{8}$ in. up to 18 in., including diameters suitable for use in boilers. Here the average length is about 12 ft., although any other length can be manufactured if required. The tubes for very long lines can be partly corrugated.

In steam-pipe lines, contraction and expansion caused

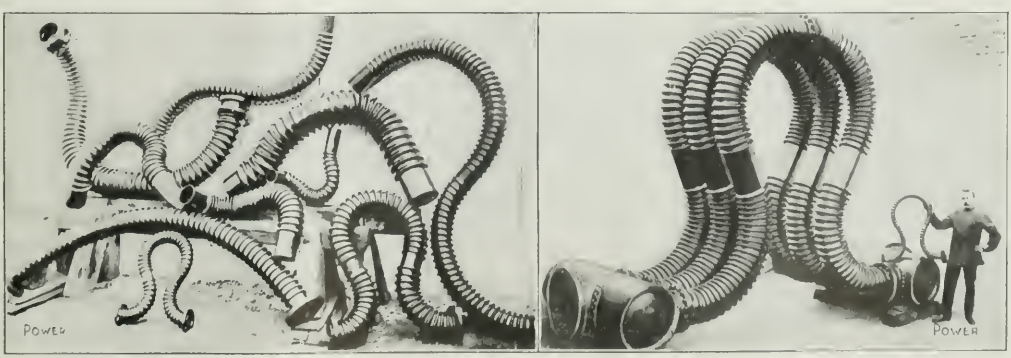


Fig. 1. Examples of Corrugated Tubing

by the steam, vibrations of the engines, pumps and other units are effectively taken care of by the elastic property of the tubes. In fire-tube boilers, a greater heating surface is secured, and the strain removed to a large extent from the tube sheets and the combustion chamber. In superheaters, the heating surface is increased and in radiators for steam- and for hot-water heating systems, owing to the large outside surface, more heat is given off than with ordinary straight pipes, consequently smaller radiators can be used.

Another advantage is where the space for expansion and contraction is limited and large bends cannot be made. When steam is turned on or off there is a wide variation in the temperature; hence there is considerable linear movement in the line and its branches to the various units. This movement is easily taken up by a length of this corrugated pipe.

On account of the easy bending properties of corrugated tubes very small radii can be obtained having a large amount of elasticity. For instance, a smooth pipe 10 in. in diameter, having a height of 108 in. and a 108-in. throat, has a maximum expansion of 2 in. A corrugated tube of the same diameter but only 63 in. high and a 55-in. throat, has an expansion of 5½ in. Hence a pipe line having an expansion of 5½ in. would require three

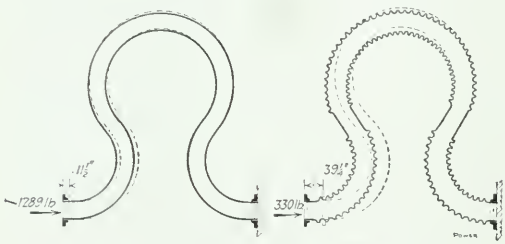


FIG. 2. DIFFERENCE IN PIPE MOVEMENT

bends of smooth pipe with a combined length of about 81 ft., or only one corrugated tube 12 ft. long.

In Fig. 2 an ordinary 6-in. pipe is shown, bent in the shape of a loop, one end being fixed and the other free to move.

When subjected to a lateral pressure of 1289 lb. the axial movement was 11½ in. A corrugated pipe of the same size and thickness was bent and fastened as the plain pipe; on applying 330 lb. pressure there was an axial movement of 39¼ in., or over three times that of the smooth pipe.

The process for making this corrugated pipe is patented in Europe and the United States by N. Maciejewski. The pipe is being made in Russia, Germany, Belgium and France. The United States patents are for sale by Schuchart & Schutte, 90 West St., New York City.

The coal-production figures of 1912 are being compiled as rapidly as possible, and from reports already received it appears that the total output of Alabama mines will be well over 18,000,000 tons, which is approximately a 21 per cent. increase over 1911. This abnormal increase in coal consumption bespeaks the wonderful industrial progress now being made in Alabama and adjacent states. Many new mines are being opened with the expectation of getting a goodly supply of the coal business that will naturally develop in connection with the Panama Canal trade. If adequate shipping facilities are furnished, the year of 1913 will show a substantial increase over last year.—"Coal Age."

The Flow of Steam through Pipes

By H. V. Carpenter*

Judging from the comments I have received since the publication of the charts representing the flow of steam (Power, Dec. 17, 1912, page 889), it appears that the following charts covering much lower pressures and larger pipes may be of interest: The charts now given cover pressures from 0.4 in. of mercury, absolute pressure, up to 25 lb. per sq.in. absolute, and pipe sizes from 2 to 60 in. in diameter; while those previously published covered pressures from 6 to 500 lb. per sq.in. and pipes from 1 to 20 in. in diameter.

The original experiments do not give sufficient data to warrant the use of the formulas over as wide a range as is covered by the charts shown here, but the results seem to check quite well with practice so they can perhaps be accepted as representing the truth as closely as is possible at present.

As before, the method of reading the charts is shown by the heavy dotted lines; for example, following the dotted lines on the velocity chart, it is found that if the loss of pressure is assumed to be 1 lb. per 100 ft. of pipe, in a 12-in. pipe, and the absolute pressure is 5 lb. per sq.in. at the middle of the pipe line, then the velocity of the steam will be a little over 41,000 ft. per min.; or, if the pressure is 3 in. of mercury the velocity will be nearly 74,000 ft. per min.

In a similar way the quantity chart shows that, with a drop of 1 lb. per 100 ft., in a 12-in. pipe, and an average pressure of 5 lb. per sq.in., the quantity of steam delivered will be 440 lb. per min.; or, if the pressure is 3 in. of mercury, 250 lb. per min. will be delivered; or, if the pressure is 1 in. of mercury, 150 lb. will be delivered.

The charts may, of course, be worked in any direction so that if any three of the quantities are known or assumed the fourth may be determined.

It will be noted that by using both charts for the same case the velocity required to deliver a given quantity of steam per minute may be determined; for example, in the first case given above it follows from the results obtained with both charts that to deliver 440 lb. of steam per min. through a 12-in. pipe at an average pressure of 5 lb. absolute, a velocity of 41,000 ft. per min. will be required.

All of the charts are calculated for saturated steam. There should be little error, however, in their use, for superheated steam provided that instead of the actual pressure of the superheated steam we use the pressure at which saturated steam has the same weight per cubic foot.

In the calculation of the charts it has been assumed that the nominal diameter of the pipe is its actual diameter. The error due to this will not be noticeable, except, perhaps, for piping over 12 in. in diameter, which is rated by its outside diameter. In these larger sizes the actual inside diameter should be used in applying the charts.

If it should be desired to apply the charts to pipes which are not circular in cross-section, it would be necessary to calculate the hydraulic radius (cross-section divided by perimeter) of the conductor. This multiplied by four would be the equivalent diameter.

The enormous velocities which the velocity chart shows to be permissible at low pressures emphasize the need of avoiding sudden bends or offsets in condenser piping.

*Professor of mechanical and electrical engineering, State College of Washington.

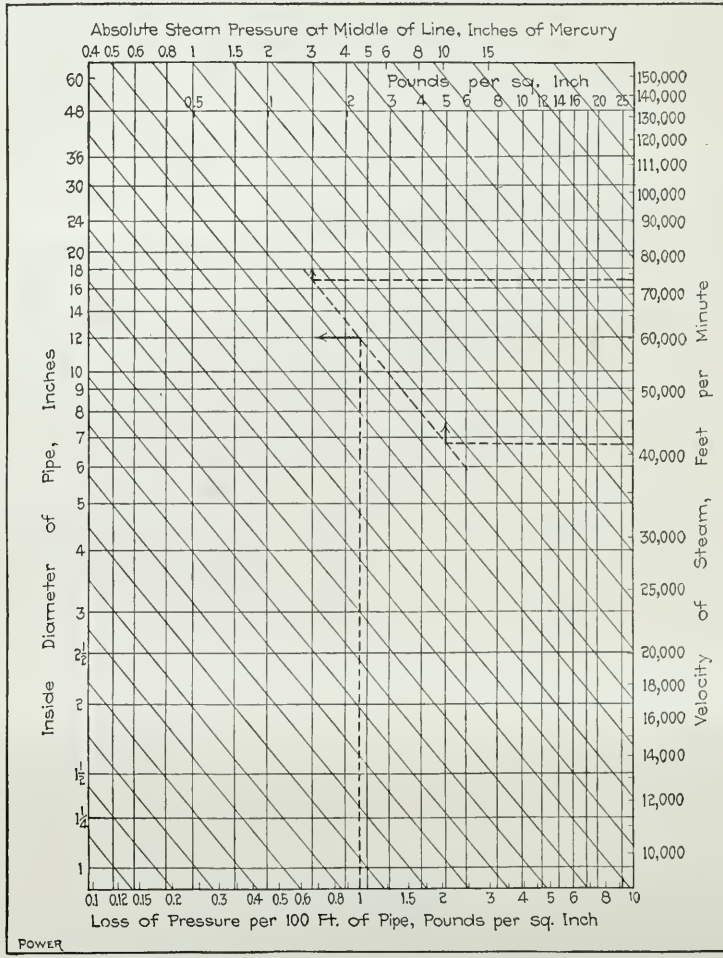

Absolute Steam Pressure at Middle of Line, Inches of Mercury
Pounds per sq. Inch
Inside Diameter of Pipe, Inches
Velocity of Steam, Feet per Minute
Loss of Pressure per 100 Ft. of Pipe, Pounds per sq. Inch
POWER

Chart Showing Loss of Pressure of Steam Corresponding to Given Pipe Size, Pressure and Velocity

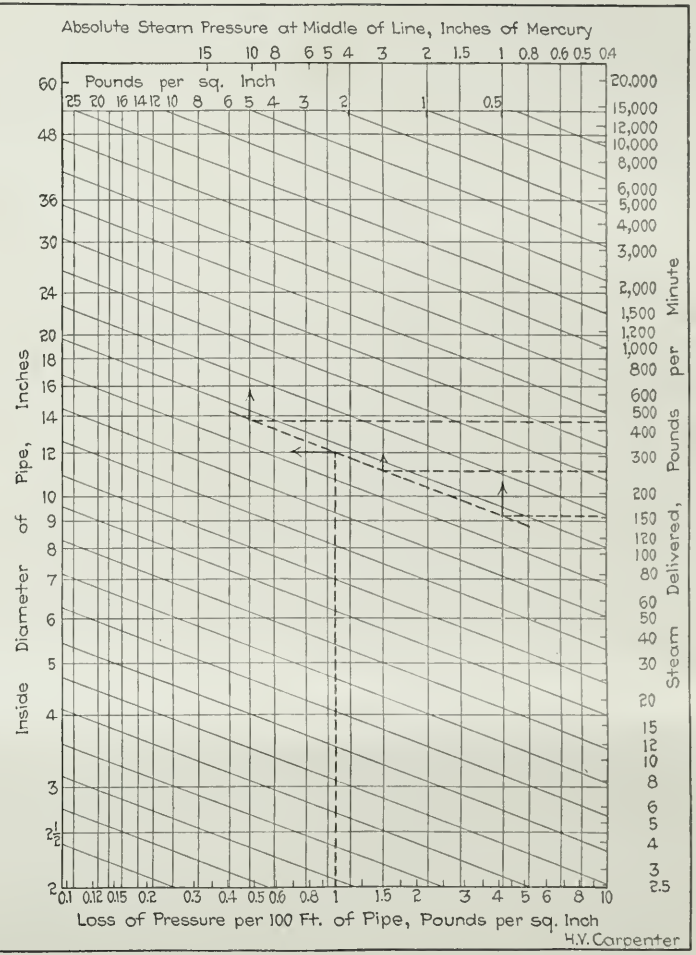

Absolute Steam Pressure at Middle of Line, Inches of Mercury
Pounds per sq. Inch
Inside Diameter of Pipe, Inches
Steam Delivered, Pounds per Minute
Loss of Pressure per 100 Ft. of Pipe, Pounds per sq. Inch
H.V. Carpenter

Chart Showing Loss of Pressure of Steam Corresponding to Given Pipe Size, Pressure and Amount Delivered per Minute

ELECTRICAL DEPARTMENT

Sparking

By E. F. Butler

In the operation of electrical machinery and particularly in the case of direct-current generators and motors the fault most commonly met with is sparking at the brushes. There are in all about thirty causes for sparking, a number of which are due to faulty design or errors in erection. These will not be considered here, but instead, only those classed as operating faults. The following remarks apply only to machines fitted with carbon brushes as these are in the majority.

Probably the most frequent cause of sparking is overloading. An ammeter in circuit is the most reliable guide to this. The sparks from an overload are bluish white and extend the whole width of the brush. All the brushes, as a rule, sparking equally. If the overload be increased the sparks will get longer and longer until an arc is set up from holder to holder. This is known as a "flash-over" and in the case of a motor may burn the brush gear and damage the armature. In a generator it will

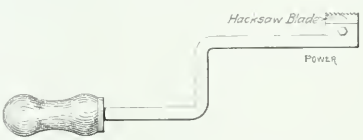


Fig. 1

have the effect of short-circuiting the armature. Usually no damage will result electrically as this will destroy the magnetism of the fields and so bring the voltage down to zero, but a sudden and severe strain is put upon the driving end of the machine. The remedy is, of course, to find and remove the cause of the overload.

Another common cause of sparking is high or low segments or mica. As the brushes pass the faulty places they jump and partially break the circuit, this results in flashing or arcing, and the faulty bar and those near it will be rough and blackened.

Very little can be done with bad segments except to change them. In the case of high bars of mica, take out the armature and turn up the commutator in a lathe, first wrapping the winding near the commutator to prevent turnings getting in and lodging at the back of the commutator. After this has been done make a tool as shown in Fig. 1 and recess the mica $\frac{1}{32}$ to $\frac{3}{64}$ in.

The cranked shape is useful for getting at a commutator without removing the armature. Oily or dirty commutators are also a common cause of sparking and here the remedy is usually obvious. Points to note in machines which have a tendency to throw oil are that the oil grooves do not extend right through to the inner edge of the bearing, that the overflow is not choked up, and also that the oil is not too thin at the highest temperature of the machine.

Vibration, more especially in motors, is a common cause of sparking. It may originate either in the machine or from some external source. First examine the pole-pieces to see if they are tight; also the foundation bolts. Note if the bearings are worn; if so, they are likely to rattle. See if the shaft is bent or sprung. Moreover, a pinion too deep in the gear or badly worn may cause the vibration. Rawhide or paper pinions sometimes work along the shaft and run on the metal shrouding. In the case of belts flapping, bad joints should be looked for. Try the armature for endplay; if this is excessive, turn a washer, preferably of brass, of such thickness as to leave about $\frac{1}{32}$-in. endplay. Place this on one end of the shaft so as to bring the brushes about central on the commutator.

Excessive vibration will often cause the coils to break near where they are soldered to the commutator. Sparking due to such an open circuit in the armature cannot very well be mistaken. It is a vicious green, due to the arc set up between two adjacent segments, and shows itself as a ring of fire often extending all round the armature. On stopping the machine the burnt portion is very evident. In a four-pole machine it will be noticed that two places are marked, although there may be only one break. If the disconnected end of the coil can be seen it can often be repaired at once with a soldering iron. When a temporary repair is necessary to keep the machine going, bridge the burnt segments. If it is a four-pole machine start up and watch closely to see if it smells or smokes. If it does, then the wrong pair has been bridged. Clean them out and scrape the mica between them until it shows clear, then bridge the other pair of burnt-out segments and when making the repair permanent, do not forget to clean them.

Of the purely electrical causes of sparking the most common is the wrong position of the brushes. Frequently the brush gear is insecurely clamped and it works around into the wrong position. The writer recalls a case of a four-pole shunt machine of 15 hp., which on test at full load was observed to spark badly at one set of brushes, while the other three were all right. On moving the rocker the sparking at this set disappeared, but the other three sets started sparking. After an inspection had been made, a band of paper was pasted around the commutator and divided off equally into four parts; it was found that one set of brushes was not diametrically opposite the other, the rocker casting being at fault.

Faulty field coils are another cause of sparking. Sometimes oil in the bottom of the motor case will rot the insulation and either ground or partially short-circuit them. With faulty field coils, in addition to sparking, the speed is often excessive and the motor does not start up well. This is often a clue to the trouble. If there is a ground on the field coils and one of the main leads is also grounded, either by accident or otherwise, the trouble may be located by feeling the coils and noting whether some of them are hot and others cold.

Brushes also spark, owing to too little tension or from too much tension. About 2 lb. per sq.in. is correct for most motors, although for traction and railway motors up to 6 lb. is sometimes necessary. Some brushes are copper-plated, and if they happen to wear so that the copper gets onto the commutator, sparking will be set up and the commutator will be roughened. Dirt and grease will cause the brushes to stick in the holders; also, if they are at all tight they are likely to swell when hot. If, on the other hand, they are too slack, they will wobble in the holder and become rounded at the end, and sparking will result because of insufficient contact with the commutator.

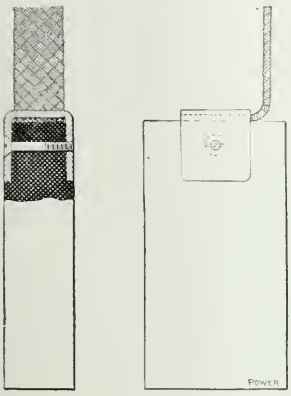


FIG. 2

A brush is right when it will just slide through the holder onto the commutator by its own weight. When many brushes are used it is cheaper to make a gage and reject those not of size. Too little tension is sometimes due to the springs becoming weakened by the current passing through them. This is usually due to bad design and every brush should be fitted with tags or pigtails to shunt the current from the springs.

A traction motor which not only burnt up springs, but two sets of holders in less than six months was cured in this way. The brushes were filed $\frac{3}{32}$ in. deep and $\frac{3}{4}$ in. down on both sides. A piece of $\frac{1}{16}$-in. strip copper was bent to form three sides of a square, fitted over the field portion of the brush, drilled and countersunk. A piece of dynamo flex was placed between the top of the brush and the strip, squeezed down and a bolt put through and fitted with a countersunk nut. To make all secure the end of the bolt was lightly riveted to keep the nut from working off. The other end of the flex was clamped under a setscrew tapped into the body of the brush-holder. The copper tip did not extend the whole width of the brush as the tension spring only pressed on the center. This gave room for the flex to be brought up alongside. Fig. 2 shows how this was done.

Liquid Rheostats for Large Alternating-Current Motors

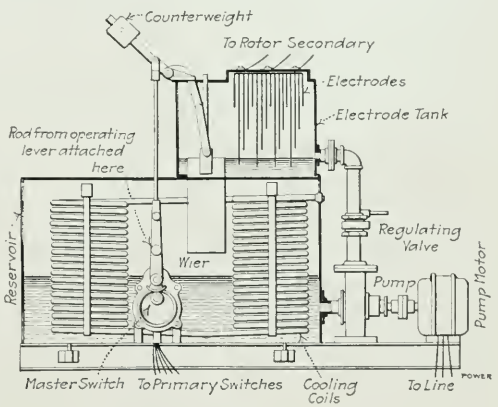
The use of large alternating-current slip-ring motors for driving mine hoists, winding gears, rolling mills, etc., has increased largely during the past few years and has created a demand for a simple, efficient and economical controller. To meet this demand the Westinghouse liquid rheostat has been developed.

These rheostats provide an infinite number of steps between the minimum and maximum limits, thus permitting the fine speed adjustments and very smooth acceleration.

The rheostat consists of two compartments, an upper tank for the electrodes, and a lower reservoir. The three phases of the rotor are connected to electrodes suspended in the upper tank. A small motor-driven pump pumps a steady stream of liquid, usually a solution of soda, from the reservoir into the electrode tank, and back into the reservoir over a weir. By raising or lowering the weir, the height of the liquid in the electrode tank is correspondingly varied. The resistance in the rotor circuit decreases as the liquid level rises, and *vice versa*, and the motor speed, of course, changes with the rotor resistance.

The primary circuit of the motor is closed and opened by means of electrically operated switches, which are controlled by a master switch mounted on the rheostat.

The operating lever of the rheostat controls both the master switch and the weir. When the lever is in its central, or off, position, the primary switches are open and the weir at its lowest level, so that the secondary resistance is a maximum. Moving the lever in one direction closes the proper primary switches for starting the motor forward and raises the weir. Moving the lever in the opposite direction reverses the motor and again raises the weir.



SECTION THROUGH RHEOSTAT

Speed control is secured by varying the position of the weir by moving the lever; the primary switches do not open until the lever is placed in the off position.

A valve in the intake pipe of the electrode tank regulates the rate at which the liquid is pumped in, so that no matter how quickly the operating lever is moved, the liquid can only rise at the rate for which the valve is adjusted, thus fixing the rate of acceleration. When the lever is returned to the off position, the weir drops and the liquid level promptly falls.

Cooling coils in the reservoir prevent rapid evaporation of the liquid.

These rheostats are made in capacities of from 400 to 1500 horsepower.

CORRESPONDENCE

Static Charges on Belts

In the Apr. 15 issue is a letter, by L. A. DeBlois, discussing static charges on belts. For nearly 16 years I have had to do with belts and have never known a case where static electricity in a belt could not be entirely cured by treatment with Cling-Surface. In one instance a belt driving a generator supplying current to arc lights in a large railroad shop produced a heavy static charge in spite of an attempt to ground it by means of chains dangling very close to the belt. After the first Cling-Surface treatment the chains were removed and the belt never again showed a static charge.

CHARLES F. CHASE.

Philadelphia, Penn.

Hollow Conductors

In the May 13 issue there is an article by Clifford B. Parliman entitled "Alternating-Current Conductors," which takes up what is known as "skin effect" and the way of overcoming it.

His description of the cause of skin effect is hardly what I have been taught to believe, and I should think that a more accurate statement would be to say that the sudden increase in the amount of current flowing in a conductor, from zero to a maximum, then down to zero, and then to a maximum in the other direction when alternating current is used, sets up counter electromotive forces due to the cutting of flux in the material. At the center of the conductor these counter electromotive forces are stronger than at the circumference so that it is harder for the currents to get started there. As a result the current is flowing at the outside for an appreciable time before it begins at the center and with a high-frequency current the reverse comes too soon for there to be much current in the center of the conductor at any time.

On account of the permeability of an iron wire, there is with it considerable skin effect, but with copper and aluminum the effect is very slight except when large conductors are used and the frequency is much higher than usual.

The heating mentioned by Mr. Parliman as taking place in solid conductors transmitting alternating current is no greater than would occur with direct current if the resistance of the conductor were increased in a proportion equal to the apparent resistance of the wire mentioned by him. The only result of the skin effect is to increase the resistance slightly due to the current not being at its maximum density in the center of the wire or bar.

The footnote to the article in question mentions "Fos-[illegible]" and if the tables given there are con-[illegible]n what a very little difference the [illegible] in the apparent resistance of a wire [illegible]d frequencies and sizes of wire. Even [illegible]re, a large size for high-tension trans-[illegible]ycles, the apparent increase in resist-[illegible]ne-half of 1 per cent. While the New [illegible] might be interested on account of the very large currents handled by it, yet the feeders are tapped off the busbars so that each part of the busbar carries but a small portion of the entire current generated at the station and as that current is generated at 25 cycles the apparent resistance will be much less than would be the case with a 60-cycle station.

Hollow busbars were used by the Philadelphia Edison Co. at least 12 years ago. In Philadelphia it was admitted that so far as the influence on the skin effect was concerned, they were not necessary, but that the use of copper tubing was preferable to wire because of its increased stiffness.

G. H. MCKELWAY.

Brooklyn, N. Y.

Care of Brushes

While boiling brushes in mineral oil or employing special self-lubricating brushes is undoubtedly a remedy for many troublesome commutators, still I question if it is always necessary to resort to these means. In most cases if the engineer will start off with a true and smooth commutator and properly fitted brushes, which require only a minimum tension on the springs, and will refrain from using patent dressings, but simply touch over the commutator occasionally with a piece of pure paraffin wax and then wipe with a clean rag, he will soon have a good brown surface and brushes requiring minimum attention.

Tension on the brushes should be set by the aid of a small spring balance, so that all the brushes will bear with an equal pressure. This refers especially to high-speed machines; the pressure will vary from about 8 to 10 oz. per sq.in. of brush surface in slow-speed machines up to 1¼ lb. in the high-speed types.

Moreover, the brushes should be of such a fit in the holders that they will freely slide up and down without rattling and on no account should the brush-holder be relied upon to conduct the current to or from the machine. The current must be cared for by flexible leads carefully fixed into the brush, if possible running the full width of the brush so as to prevent local heating.

EDWARD RUSSELL.

Rochdale, England.

Briquetted fuel manufacture in the United States is passing out of the experimental stage. The production in 1912 was 220,064 short tons, valued at $952,261. Of the 19 briquetting plants operating, seven used anthracite culm, nine bituminous slack, one carbon residue from gas manufactured from oil, one mixed anthracite culm and bituminous, and one used peat. One plant at Detroit and one plant at Philadelphia, constructed for utilizing coke breeze, were not operated in 1912, the abrasive action of the coke dust being so destructive of the molds and machinery that the plants have been shut down.

The quantity of raw material available for briquets is ample and obtainable at little cost. The briquetting cost is $1 to $1.25 per ton. Slack piles at many mines have sometimes been burned to prevent cumbering the ground. The 220,064 tons of briquets made in 1912 represent but a drop taken from the bucket of available material.—*Geological Survey's "Mineral Resources in 1912."*

GAS POWER DEPARTMENT

Operation of Gas Engines Using Blast-Furnace Gas*

By Charles C. Sampson

The operation of gas engines using blast-furnace gas includes several important factors outside the actual operation of the engines themselves. One of the most important of these is cleaning the gas. As delivered by the furnaces it contains normally from 3 to 10 gr. of dust per cu.ft., but at times of slips or other sudden changes in the furnace, it carries much more. For use in engines the gas must be cleaned to at least 0.02 gr., but even this figure is too high to satisfy the operating engineer since it is possible to clean the gas to 0.005 or 0.006 gr. per cu.ft. with great benefit to the engines.

The method of cleaning most used at present has three stages: (1) Dry cleaning to 1½ or 2 gr. per cu.ft., which is always done by the blast-furnace department: (2) primary washing in static washers to about 0.15 gr. per cu.ft.; and (3) dynamic or mechanical cleaning in highly developed machines to 0.015 or less. The last stages are usually handled by the gas-engine department.

Dry Cleaning

Dry cleaning is done in dry-dust catchers, the standard design being a vertical, cylindrical shell of large diameter into which the gas enters tangentially near the top and leaves through a vertical outlet pipe extending about two-thirds down from the top. These dust catchers remove the heavier particles of dust, but their efficiency is only about 80 per cent., as they are apt to pick up, or perhaps do not drop, the finer dust, which is carried on by the upward current of gas to the outlet.

Sudden changes in the direction of flow of the gas, as at water seals or other bends, are quite efficient in the removal of dust. In one case gas carrying about 5 gr. per cu.ft. passed through four sharp bends and reduced the dust content to 2 gr. per cu.ft. For this reason every part of the dry-gas main where such bends are necessary can be made to assist materially in cleaning the gas, if pockets and valves are provided, so that the dust can be conveniently removed.

Where long gas mains are necessary, they can be made to add to the cleaning of the gas by building them in successive lengths with sufficient rise and fall to allow the dust to settle in pockets at the bottom angles. If the gas for any reason moves slowly in a long main the loss of heat through the pipe will probably reduce the temperature below the dew point and thus condense some of the moisture and cause the deposit of wet dust, which adds greatly to the cleaning-plant labor. This is especially apt to occur where two or more groups of furnaces supply one washing plant; the gas from the one with the lower top pressure will move slowly, or even reverse its direction of flow at times, allowing excessive cooling and the resulting condensation. This condensation will begin when the temperature is reduced to 115 or 120 deg. F.

Primary Washers

The present primary washers (the first stage of wet cleaning) are of the static scrubber type and include all those in which the gas passes through a stationary shell without moving parts, the water for washing being supplied either in spray or sheets. The spray and hurdle, Mullen, baffle, and rain-type scrubbers come under this classification.

The spray and hurdle system is preferred on account of its better distribution of water, and since it is self-cleaning it needs inspection only after long periods of operation. In the rain or baffle types the gas is more apt to channel and travel up one side of the scrubber and the water down the other.

Two outlets at opposite sides of the top are better than one on account of the deflection of the water by the gas currents if only one is used. This is particularly true if the water is sprayed by falling on spray plates as the gas current may then be strong enough to blow the water clear of the plate and thus entirely lose its effect. Spray nozzles are not subject to this fault, but are not able to handle water that has much dirt in it without considerable attention.

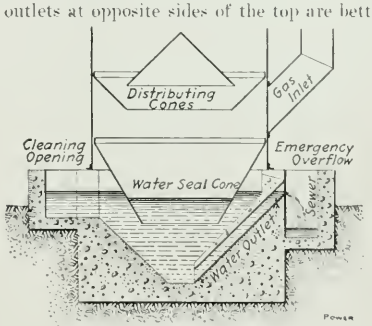


Fig. 1. Scrubber Bottom

In designing the scrubber bottom, its foundation and the basin and overflow for the outlet water, it must be remembered that while the usual working pressure will be from 6 in. to 18 in. of water, a slip will give pressure of from 40 in. to 50 in. for a short time. A normal head of water of 36 in. from the bottom of the scrubber to the water-overflow level with the basin walls 24 in. above this and an emergency overflow 1 in. below the top of the basin walls will care for slip pressures without blowing out any gas or overflowing the basin. Fig. 1 shows this arrangement of scrubber bottom.

Should the water-overflow pipe be stopped, the heavy mud will settle to the bottom, and when the overflow pipe is cleaned there will be such a quantity that even the extra head of water to the emergency overflow will not force it out. For this reason the forming of heavy chunks must

*Excerpts from a paper read before the American Society of Mechanical Engineers, May 21, 1913

be prevented as much as possible and provision must be made for stirring the basin water both with hoes or rakes and with a stream of water.

Mechanical Scrubbers

The final stage in cleaning is done with mechanical scrubbers. These are highly developed and the Theisen patented gas washer has been in the lead for several years, although other types are now being worked out, their builders claiming better results with less water and power. The Theisen washers require about 3 per cent. of the power output, and from 16 to 18 gal. of water per 1000 cu.ft. of gas cleaned, which added to the 75 to 80 gal. required in the scrubbers makes the total from 90 to 100 gal. for the whole cleaning process. The newer apparatus claim to use about 20 gal. of water per 1000 cu.ft. of gas for the whole cleaning process.

Holders

In blast-furnace gas-engine plants the engines are entirely dependent upon the continuous supply of gas from the furnaces; a 100,000-cu.ft. capacity holder can only be

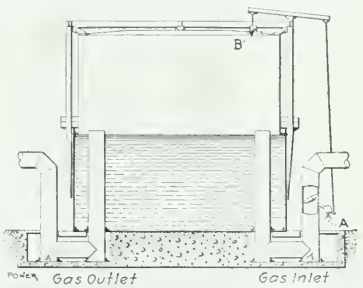


Fig. 2. Gas Holder with Regulating Valve

considered a pressure regulator with capacity for enough gas to allow retiring in good order when the gas supply is cut off for any reason. Thus in a 1000-kw. plant with such a holder the gas on hand would operate the plant only for about 25 to 30 min., and should not be counted on for more than 15 to 20 minutes.

The quantity of gas consumed by the engines is regulated by the governor to suit the power output, but since they must be supplied with gas at uniform pressure, it is necessary to regulate the gas supplied by some type of gasometer. This is best done by a gasometer of such capacity that the pressure fluctuations are not noticeable at the engines, and since it is well to have an emergency quantity of gas, the holder itself will meet both demands at once if supplied with an efficient regulating valve.

There should also be the possibility of regulating the gas quantity at the secondary washers since at times of very light loads the gas pressure between the holder and washer may blow out drip seals or cause dangerous gas leaks. This can be cared for by the installation of butterfly valves with quadrants either before or after the mechanical washers. The latter is to be preferred, for then the gas remains longer in the washers and receives additional cleaning.

A good regulating valve at the holder is a butterfly valve attached by means of levers and cables to the holder bell, so that it will remain wide open until the bell rises within a few feet of its upper position, and closes gradually until at the highest position it is completely closed. The arrangement shown in Fig. 2 works satisfactorily. The weight A must be heavy enough to close the valve, and the weight B must be heavy enough to open the valve and also lift the weight A.

All exposed water lines must be protected from freezing. This is especially true of the supply to seals, drips from the gas main, and any line that does not have a continuous flow. With good water separators after the secondary cleaning apparatus, freezing weather, or even 8 or 10 deg. F. below zero, will not cause trouble in the gas mains themselves, though any valves which may be nearly closed or which are closed part of the time must be carefully protected.

The water in the gas holder must also be warmed. The exhaust from the regulating valve coil will easily keep the holder water warm enough to prevent freezing, except in the coldest weather, when it is usually necessary to supply additional steam.

The holder water, if too hot, will charge the gas with water, so that condensation and freezing will take place in the supply pipes to the engine. When the water circulates properly in the holder it is not necessary to have it any warmer than 38 or 40 deg. F., while a rise to 65 or 70 deg. may give trouble.

Starting the Engines

Compressed air at from 150 to 200 lb. per sq.in. has proved satisfactory for starting gas engines. In a starting system of 2000 cu.ft. capacity the air pressure is lowered about 20 lb. in starting one 3000-kw. twin-tandem unit, and since 150-lb. pressure is sufficient for a start, there is a possibility of at least three starts from 200-lb. initial pressure. After the engine operator becomes familiar with the operating peculiarities of the engines he should be able to start them at intervals of from 4 to 8 min., and not lower the air pressure more than the compressor can make up in that time.

For the ordinary blast-furnace gas-engine plant of from three to six engines, two air compressors of 100-cu.ft. capacity and air-tank capacity of 2000 cu.ft. are sufficient, while for more than six engines the compressor capacity should be increased rather than the tank.

Lubrication

For general lubrication, such as main bearings, crosshead and crankpins and crosshead slides where the rubbing surfaces are at room temperature, an oil of the following physical characteristics gives excellent service.

Specific gravity	0.888
Viscosity (Tagliabue)	210 at 70 deg. F.
Cold test	35 deg. F.
Flash temperature	435 deg. F.

Because of the mixing of water from the cooling system with the oil, it is necessary to provide means for separating the water and oil in the filtration process, and this can be done thoroughly only by heating the oil to about 160 or 190 deg. F., and giving it time in a quiet condition to allow the separation. A large part of the dirt will settle with the water. Such that does not must be removed by filtration through fine cloth of organic fiber or through fine wire.

A good oil-cleaning system giving excellent satisfaction consists of one 1500-gal. water-separating tank, shown in Fig. 3, with a heating coil over which the oil flows as it enters on returning from the engines, and an

adjustable automatic water overflow to discharge the separated water, two settling tanks of the same size through which the oil passes in tandem to allow time for quiet settling of dirt particles, and a filter unit with 20 filter bags, 10 each in two filter tanks.

An extra tank is provided for use when either of the other three is out of service for cleaning. An auxiliary tank of about 200-gal. capacity is used for "boiling up" the sludge taken from either of the large tanks or the filters at the time of cleaning, as well as such dirty oil as can be drawn off daily from the overhead oil tank.

The varying cleanliness of the gas, hardness of cylinder walls and piston rings, piston speeds, mean effective and maximum pressures all have their influence on the action of the cylinder oil. An oil showing a specific gravity of

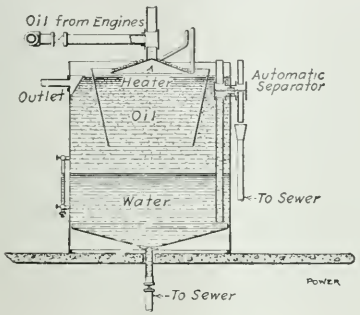


Fig. 3. Water-Separating Tank for Oil-Cleaning System

0.902; viscosity (Tagliabue) of 78 at 212 deg. F., and a flash temperature of 380 deg. F, gave excellent results in a gas blowing-engine plant where the dust was low (0.01 or less), and the piston speed less than 600 ft. per min., but was not satisfactory in another, with 0.012 gr. of dust and a piston speed of 850 ft. per min. In the latter case the oil was replaced by one having a specific gravity of 0.920; viscosity, 203 at 212 deg. F.; and a flash temperature of 502.

Ignition

The mechanically operated igniter is much to be preferred to the magnetic type. The current supply should be from a source not liable to fluctuation, such as that from a motor-generator set that supplies current to the ignition system alone and is arranged in connection with a storage battery, so that should anything happen to the motor generator the battery would take up the load, automatically signaling the operator.

Premature ignition is usually caused by excess hydrogen in the gas, and will occur when the quantity of hydrogen reaches about 4.6 per cent., depending also upon the cleanliness of the cylinders. This premature ignition is an indication of leaky cooling plates in the furnace.

Miscellaneous

The pistons of the early large gas engines were of cast iron, but these gave considerable trouble by cracking because they were not properly ribbed. Several builders changed to cast steel, but found they gave trouble either by cutting the cylinder walls or by heading over and binding the rings.

Cast-iron snap rings of uniform cross-section give better service than any other type. Piston-rod packing furnishes one of the difficult problems for the designer and also for the operator. A good packing must be simple in design, and, as in the case with the piston rings, the forms with the fewest parts seem to give the best service. Both cast iron and babbitt have given good results.

A daily log of the various pressures and temperatures must be kept to learn whether the plant conditions are changing and to know the cause of these changes. Any unusual occurrence or the regular recurrence of repairs noted on the log sheets puts the information regarding the plant where it can be used in predicting and preparing for the future.

Exhaust-Valve Trouble

The engine at our factory ran very well for a few months, after which trouble began first with the exhaust valve and ending with the gear on the end of the governor spindle being stripped.

The exhaust valve was of cast steel with a solid head and hollow stem. The cooling arrangement for this valve seemed to work fairly well, but the face of the valve continually burned and gave no end of trouble. In the meantime we were experiencing trouble with the governor. We at first thought that the camshaft must be out of alignment, accordingly when closed down on Sunday we set to work about the camshaft. This was jacked up enough to take out the center bottom brass; the old babbitt was removed and the bearing rebabbitted, allowing a heavier setting than before, also a new gear of special temper was fitted onto the governor spindle.

When started again the engine ran very well without load for about an hour, but as soon as the load was put on, it refused to carry any more than half its capacity and the center bearing showed a tendency to run hot.

While we were having our troubles with the engine, a new exhaust valve had been designed by the head machinist. This valve was made in two pieces, the head being of cast iron and the stem of steel. The head was hollow to allow sufficient space for a water jacket, the cooling water passing up one side of the stem through the valve jacket and down the other side of the stem. This type of valve has been giving satisfaction for a long time now, but we have to keep two or three on stock, so far. The stem is riveted over inside the valve head, and is apt to become loose. One valve will run a month, night and day, without grinding.

I am of the opinion that the whole trouble was in the exhaust system, the steel valve not seating right allowed burnt gases to be drawn into the combustion chamber, leaving carbon deposits on the valve and seat, at the same time throwing a strain on the camshaft, which was transmitted through to the governor spindle and caused a binding action between the shaft gears and governor gear.

This engine is running 21 hr. a day on natural gas and is giving entire satisfaction. A cast-iron valve was made recently and experimented with. This valve was cast in one piece with a water jacket in the head. A ¼-in. gas pipe was placed in the stem for cooling purposes. The water passed up the pipe and returned down inside the stem. The valve worked all right for one week, but, unfortunately, the stem broke about 2½ in. from the end.

Wallaceburg, Ont., Can. W. M. Grey.

REFRIGERATION DEPARTMENT

The Absorption System

In this department an explanation of the working of this system has been given. The description was elementary and the illustration included only the principal apparatus such as the absorber, generator and condenser. To get the best economy out of the system numerous auxiliary apparatus are required and in the present article the intention is to illustrate the full equipment of a commercial plant. Briefly, the apparatus consists of an absorber, ammonia pump, exchanger, generator, analyzer, weak liquor cooler, dehydrator or rectifier, condenser, ammonia receiver, regulating (expansion) valve, and the brine cooler. These various parts of the system may be furnished in the shell and coil, shell and tube, a vapor which passes on to the absorber. The weak liquor (most of which is water) in this apparatus has a great affinity for ammonia vapor and will absorb from 500 to 1000 times its own volume depending on its temperature and the amount of ammonia already in the liquor. When enough ammonia has been absorbed to make about 28 per cent. of the total weight, the liquid, then known as strong liquor, is pumped through the exchanger and analyzer to the generator. Here heat is applied by means of steam coils and the ammonia being more volatile than the water is evaporated and passed on to the condenser. The water, or rather weak liquor, as there is still some ammonia left in it, is returned through the exchanger and a weak liquor cooler to the absorber.

In the illustration a double-pipe exchanger is shown.

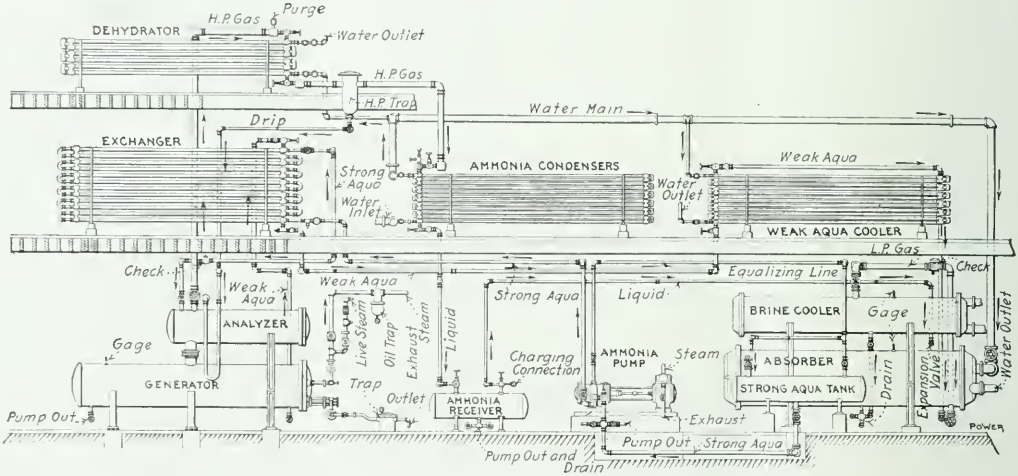


Fig. 1. Typical Layout of Absorption System with Double-pipe Auxiliaries

atmospheric or double-pipe counter-current types. Depending on the composition of the cooling water, space available and other factors, a choice is made of these types, but whatever the construction, the different designs serve the same purpose.

For illustration a commercial system using double-pipe counter-current auxiliaries will be taken, although the shell-and-coil apparatus of the vertical type occupy less room and have been more generally used in small plants.

In describing the accompanying illustration, we will start with the ammonia receiver which collects the cold liquid ammonia from the condenser. This tank is under the same pressure as the condenser and when the valve at the tank and the regulating valve at the brine cooler are opened, the liquid ammonia is forced into the coils of the brine tank. Here it absorbs heat from the brine and, as explained in the previous article, changes into

The cold strong liquor on its way to the generator passes through it in one direction and the hot weak liquor goes back to the absorber in the opposite direction. An exchange of heat takes place which adds to the efficiency of the plant. In the generator the strong liquor must be heated, and part of this heat might better be supplied by the weak liquor which must be cold before it gets back to the absorber. The exchanger does not remove all of the heat so it is necessary to use the weak liquor cooler to lower the temperature of the liquor. As will be apparent, the same water used in the condenser is passed on to the cooler, and then to the absorber itself, where the weak liquor is finally reduced to the proper temperature. The weak liquor enters the bottom of the absorber and when saturated with vapor passes into the strong liquor tank, which is used in this particular case. More frequently the strong liquor settles to the bottom of the absorber.

From the exchanger the cool strong liquor passes to the analyzer where it trickles over a series of metal trays or some construction which will distribute the liquid and allow it to come in close contact with the hot vapor rising from the generator. The counter-current principle of cooling is thus again employed, so that with an analyzer of large capacity the strong liquor should be very near the boiling point by the time it reaches the generator. On the other hand the vapor is cooled and the condenser is relieved of part of its work.

Where ammonia liquor is boiled not only ammonia vapor, but also a small percentage of water vapor is formed. This mixture, if condensed, would form a strong ammonia liquor, which would cause disturbances in the cooling coils by the formation of ice. When the vapor mixture meets the cooler strong liquor in

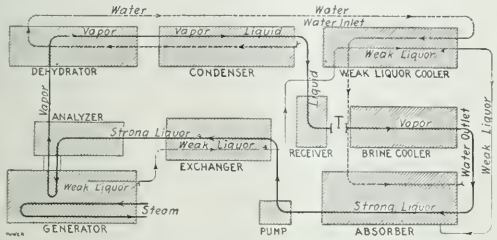


Fig. 2. Tracing the Ammonia, Weak Liquor and Water

the analyzer some of the water vapor will be thrown down and returned to the generator. The balance is condensed in the dehydrator, or rectifier as it is more commonly called, the vapor practically free from water vapor passing on to the condenser and the moisture back to the analyzer. It may be noticed that the rectifier is nothing more than a double-pipe cooler employing the counter-current principle. In the condenser the vapor is reduced to a liquid by the use of plenty of cooling water and returned to the ammonia receiver. This completes the cycle of operation, which is constantly repeated with a fresh supply of ammonia from the receiver.

To trace the path of the ammonia in the form of liquid and vapor and also the strong liquor, Fig. 2 will help. The paths of the weak liquor and the cooling water are also shown. The apparatus of the system have been blocked in and for simplicity given a little different arrangement. The arrows on the lines indicate the directions of flow. The heavy line indicates the path of the ammonia from the receiver back to the receiver, the light line the path of the weak liquor and the dotted line traces the cooling water. The diagram is self-explanatory and may perhaps fix in mind a little more clearly the relations to each other of the various parts of the system.

Ice and Salt Mixtures

By Gilbert H. Crawford, Jr.

In certain sections of the country where ice is cheap considerable commercial refrigeration is accomplished by the use of freezing mixtures of crushed ice and salt. While this branch of the refrigerating industry is comparatively small it is of enough importance to warrant an occasional discussion.

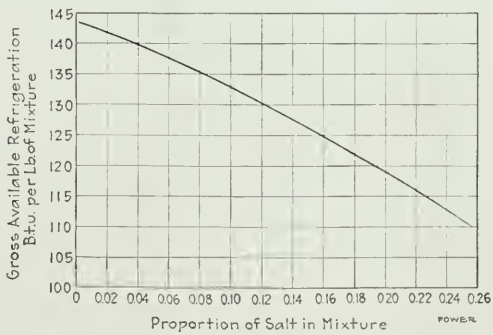
The action of common salt (sodium chloride) and ice is to lower the mixture temperature below 32 deg. The depression of temperature depends mainly on the proportion of salt used, and partly on the rate at which heat is supplied from the outside. The following table gives the approximate temperatures resulting from the use of different proportions of salt and ice.

Per Cent. of Salt in Mixture	Temp. of Mixture, Deg. F.
5	26.6
10	19.9
15	11.8
20	1.6

The minimum temperature obtainable with ice and salt is about —7.5 deg. F., this temperature being given by a 24 per cent. mixture.

In melting, the ice absorbs its latent heat of fusion at the rate of 144 B.t.u. per lb. of ice melted. The salt on dissolving also absorbs heat—called the "heat of solution," which varies in amount, depending on the density and temperature of the resulting brine.

As steam quantities are calculated from and at 212 deg. F., so it is convenient to calculate the available refrigeration due to the melting of an ice and salt mixture from and at 32 deg. F. The accompanying curve shows the relation between the proportion of salt in an ice and salt mixture and the available refrigeration per



Refrigeration Available with Varying Percentages of Salt

pound from and at 32 deg. F. Corrections to the available refrigeration must be made if the salt is added to the ice or if the resulting brine be allowed to escape at temperatures other than 32 deg. F.

These corrections are easily calculated by multiplying the weights of salt and brine by their respective specific heats and by their temperature differences from 32 deg. F. The specific heat of dry salt may be taken at 0.214 B.t.u. per pound-degree. The specific heat of salt brine varies with its density and may be taken from the following table:

Per Cent. Salt	Specific Heat of Brine
0	1.000
5	0.945
10	0.916
15	0.874
20	0.832

If the salt is warmer than 32 deg. F. when added to the ice—the usual case—the correction for its heat above 32 deg. F. must be subtracted from the available refrigeration. Likewise the correction is negative for the refrigeration thrown away if the brine is discharged to

waste at a temperature lower than 32 deg. F. If the brine is allowed to absorb heat until its temperature is raised above 32 deg. F. before discharge, its correction is added to the available refrigeration.

This may all be expressed algebraically as follows:

$$H' = H - 0.214\ p\ (t_s - 32) - C_b\ (32 - t_b)$$

where

H' = Net available refrigeration per pound of mixture;
H = Gross available refrigeration per pound of mixture from accompanying curve;
p = Proportion of salt expressed as a decimal;
t_s = Temperature of salt when added;
t_b = Temperature of brine to waste;
C_b = Specific heat of brine corresponding to proportion p.

EXAMPLE—What net available refrigeration is there in a mixture of 100 lb. of dry salt with 900 lb. of ice, when salt is 60 deg. F. when added to the ice and the resulting brine is allowed to discharge at 25 deg. F.?

$$p = \frac{100}{100 + 900} = 0.10$$

From the curve for $p = 0.10$, $H = 132.8$ B.t.u. The specific heat of 10 per cent. brine is 0.916 B.t.u. per pound-degree. Then

$$H' = 132.8 - [0.214 \times 0.10\ (60 - 32)] - 0.916\ (32 - 25) = 125.8\ B.t.u.$$

per pound of mixture.

Condenser and Back Pressures

The proper pressures for the condenser and the low-pressure side of the system is a question which every engineer has to solve for his own particular plant. In each plant the conditions will be a little different and the pressures which will give the highest economy will depend on the temperature of the cooling water, the amount of water supplied, the square feet of cooling surface in the condenser per ton of plant capacity, the temperature it is desired to maintain in the refrigerator and the amount of noncondensible gases present.

If the surface in the condenser is known to be correct and there is little trouble from noncondensible gases, then the following data given by F. E. Matthews may be taken as an approximate guide. Table 1 gives the proper condenser pressures for different temperatures and quantities of the cooling water and Table 2 the back pressures used

TABLE 1. CONDENSER PRESSURE

1 Gal. per Min. per Ton per 24 Hr.							
Temp. of cooling water, deg. F.	60	65	70	75	80	85	90
Condenser pressure, lb. gage	183	200	220	235	255	280	300
Temp. of condensed liquid ammonia, deg. F.	95	100	105	110	115	120	125
2 Gal. per Min. per Ton per 24 Hr.							
Condenser pressure, lb. gage	130	153	168	183	200	220	235
Temp. of condensed liquid ammonia, deg. F.	77	85	90	93	100	105	110
3 Gal. per Min. per Ton per 24 Hr.							
Condenser pressure, lb. gage	125	140	155	170	185	200	215
Temp. of condensed liquid ammonia, deg. F.	75	85	90	93	95	100	105

TABLE 2. BACK PRESSURES

Temp. of room, deg. F.	5	10	15	20	28	32	36	40	50	60
Back pressure, lb. gage	7	10	12	15	22	25	27	30	35	40
Temp. of ammonia, deg. F.	−13	−10	−5	0	8	12	14	17	22	26

in average practice to maintain certain temperatures in the refrigerator.

The pressures given in the tables will be close to the mark, but in some cases it may be possible to obtain a slightly higher efficiency by the cut-and-try method, that is, adjusting the pressures on both sides of the system until the maximum result is obtained. In any case the condenser pressure should be as low as possible and the back or suction pressure as high as possible and still maintain the desired temperature in the refrigerator. The range in pressure should then be made as small as possible, the action being just the reverse of a steam system where results are bettered as the range of pressure increases.

When the proper pressures have been determined it is important that they should be maintained. The easiest and probably the best way to do this is to install thermometers in the suction and discharge pipes of the compressor. Each temperature corresponds to a certain pressure and by marking or indicating in some way the proper height of the mercury column, it is an easy matter to see at a glance when the temperatures are above or below normal.

In the spring and fall when the temperatures of the air and cooling water are lower, it is possible to reduce the range in pressure from that used in the hot, summer months. To obtain the highest economy, adjustment of pressures should then be made at least three times during the season. It is a simple matter and only requires ordinary intelligence on the part of the operating engineer. A short time ago a case was cited in these columns, where the output of an ice plant was increased over 50 per cent. by raising the temperature of the compressor discharge from 104 to 240 deg. F. The latter proved to be the proper temperature for the existing conditions, and the case goes to show that it is well worth while to pay some attention to the operating pressures.

Rating Refrigerating Machines

In this country there are two generally accepted units for rating a refrigerating machine. These are commonly called the ice-melting or refrigerating capacity, and the ice-making capacity. Both are expressed in tons of 2000 lb. per day of 24 hr. When a machine is rated at one ton ice-melting or refrigerating capacity, it would mean that under an assumed range of operating temperature it would remove from the refrigerator the number of heat units equivalent to that required to melt one ton of ice at 32 deg. F. into water at 32 deg. F. The latent heat of ice has been variously taken as 142, 143, 143.7 and 144 B.t.u., but 144 B.t.u. is now the figure generally accepted. Then

$$2000 \times 144 = 288{,}000\ B.t.u.$$

is the equivalent of a ton of refrigeration per day of 24 hr. This would give 12,000 B.t.u. per ton per hour and 200 B.t.u. per ton per minute, all convenient figures to work with. The machine is supposed to work between a condenser temperature of 90 deg. F., and a temperature of zero in the expansion coils.

The ice-making capacity is a measure of the actual weight of ice made by a machine, designed for the purpose, in tons per 24 hr. For a machine not designed for ice making this unit would appear of little value, but for the sake of comparison it is approximately six-tenths the ice-melting or refrigerating capacity.

EDITORIALS

Analysis and Heat Value of Coal

With the growing unit cost of coal, continually sharpening competition and spreading enlightenment as to the principles of efficient combustion and boiler operation, increasing demand came for adequate simple means of predicting results to be expected with a given coal under a given set of conditions.

The character and heat value of a coal are two indispensable factors.

The ultimate analysis yields much information as to character, although not all that is often desired, and from it the heat value can be estimated quite closely. Unfortunately, however, the ultimate analysis is a long and complicated process, only to be attempted by a trained analyst, and the special apparatus required is expensive. Consequently, it is seldom performed in commercial work.

The proximate analysis yields less information as to character, still it is of considerable help. It gives the ash and moisture content, a knowledge of which is useful in comparing one coal with another and in selecting a coal to give the most heat for the money spent. It gives the volatile content which is useful in identification and classification. Its strong recommendation, however, is its simplicity and the ease with which it can be made. The required equipment is small and simple; twenty-five dollars will cover the cost of the apparatus with which to obtain sufficient accuracy for all ordinary purposes. The wonder is that the proximate analysis is not employed more extensively. Certainly, the information yielded, limited though it may be, is more than worth the cost of equipment and time required.

The principal drawback is that it is neither a close nor consistent guide to the heat value. This is because it does not show the oxygen content of the coal, which has an important influence on the heat value. In the Bureau of Mines Bulletin 29 on "The Effect of Oxygen in Coal" this influence is shown to be of about equal importance with that of the ash content. Thus, all methods of estimating heat value by calculation which do not take the oxygen as well as the ash into account are subject to large error even with coals from the same general district.

This fact was brought out by charting some three hundred analyses according to the heat value of the combustible and the percentage of fixed carbon in the combustible. With this system two of the three variables influencing the heat value are eliminated, ash and moisture. The third, oxygen, remains to cause a variation as high as six per cent. in the heat value of the combustible matter of coal from the same general district and containing practically the same percentage of fixed carbon.

Attempts have been made to calculate the oxygen content from the proximate analysis, at least, by elimination, but, as no good law has yet been discovered, heat-value estimates based on such attempts are subject to the same or even greater degree of error as the older and simpler methods. In time, some good law may be discovered, but it is doubtful whether it will be found to be simple enough for extensive application.

Aside from the ultimate analysis, the calorimeter is the only means at present available of estimating the heat value with reasonable accuracy and consistency. In its existing form it is more or less expensive and complicated. Before it can be popularized it must be perfected in simplicity and sold at such a price as to bring it within the means of the individual to buy. And the number of its possible users is so great that this seems well worth the effort.

The Value of Cost Keeping

The engineer in the small plant is well aware that the larger the company he may eventually work for, the closer will attention be paid to the detail, and, especially along the line of costs. The statement is made that the larger industries, with their various departments and large number of employees, can well afford to keep careful records, but the engineer in the small plant, who also frequently fills the position of fireman and general repairman, has little or no time to spend on cost records.

But consider how small a job it is to jot down a few items each day. A man who forms this habit will find his work takes on additional interest. He is anxious to read his technical paper carefully so he may grasp any ideas that will improve his plant efficiency and reduce his operating cost.

Perhaps first attention will be given to the coal pile. Although but few plants are equipped with convenient means of weighing coal, a little effort with platform scales and measurement of the coal bin will afford a method of arriving at a close approximation of daily consumption.

Next will come a desire to know the method of firing which will produce the best results. The percentage of carbon dioxide, quantity of air required for combustion, amount of unburned carbon in the flue gases, heats of combustion of carbon dioxide and carbon monoxide, etc., will appear to have a direct bearing on the plant operation. The engineer begins to investigate the chemical side of this coal that he is burning. He learns about moisture, ash, fixed carbon, percentage of sulphur, and becomes interested in the various grades of coal. Perhaps he can show the purchasing agent that sometimes a good way to buy coal is by the B.t.u. shown on test.

He will look over his boilers more carefully the next time the inspection is made. The water required for the boiler will bring to mind that his technical magazine a few copies back had something about factor of evaporation, temporary and permanent hardness of water, and also told about the loss of boiler efficiency caused by even one-sixteenth of an inch of scale.

The engineer who has started keeping a record of his operation cost will want to sell his cinders to some contractor, the revenue so obtained will appear to advantage on the credit side of his cost sheet. At the same time,

attention will be directed to the furnace grates, stokers and all firing equipment, so that dollars in heat units are not being traded for cents to the cinder-man.

Perhaps a saving can be made by having the feed water enter the boiler at a higher temperature. While working out this problem the terms latent heat of steam, heat of the liquid, heat of vaporization, etc., will become like old friends.

Next, attention will be given to the engine. Perhaps it has been some time since any cards were taken, and it will be found that one side is doing a lot more work than the other. A little valve adjustment will materially help the division. At the same time the presence of a strange hook or loop will cause the engineer to refresh his memory on the features of the indicator diagram.

The matter of lubrication will assume even greater importance when appearing on the cost records. The terms viscosity and specific gravity will be found to have some relation to the periods between each order for oils.

The various pumps in the plant may be taking more steam than they should, and perhaps a closer investigation of the subject of packing may aid in stopping both steam and water leaks, and also lead to a reduction in the packing bill for the year.

Only a few items have been mentioned which would appear on the record of operation costs. There are items which would be peculiar to every plant. What has been gained by the time taken? The engineer knows more about his plant than he ever did before.

It is only natural that the engineer who has become familiar with the actual operating costs of his plant will be anxious to inquire about what are termed overhead charges, especially those that pertain to his department. He knows that the items interest, taxes and insurance enter into power-plant cost, as well as depreciation. Perhaps he has felt that depreciation is the only one he should think about, but the engineer will do well to inform himself regarding interest, taxes and insurance, since they do have an important bearing on the present plant and will be the first to be considered when the growth of business demands either an enlargement of the power plant on the present site, or a moving to a location better suited both from a geographical and economical viewpoint.

The item depreciation may be considered as embracing physical depreciation and functional depreciation. Physical depreciation, or wear and tear, appeals directly to the engineer, since it represents the results of his care and attention to all parts of the equipment in his department. Functional depreciation, he may feel, does not apply so directly to him. However, as this represents the advance in design or the modification of machines which places on the market a machine that will perform work more economically than some which may be in his plant, it often pays to make the change, even though the old machine is still in fair or even good condition. The engineer, with his superior knowledge of the advancement of the science of engineering, can frequently point out financial leaks that would escape the man in the office.

The engineer of the small plant sometimes dreads the coming of central-station service, since he fears it will deprive him of his position. Often his fears are groundless, for when he starts keeping his own costs, and actually figures what he is accomplishing, he knows in cents or fractions of a cent per kilowatt-hour or horsepower-hour by how much he can beat the central station. A well kept cost record is a good thing to lay beside the central-station results of plant test.

As previously mentioned, only a few items have been suggested as appearing on a record of costs; every engineer can name others. But the main point is this, the engineer who has kept his costs of operation for the year systematically can show his employer results and he knows that his own engineering knowledge has become broader. Surely a habit containing such a twofold blessing is worth a little time and effort.

Boiler-Efficiency Chart

On another page of this issue is to be found a "Boiler-Efficiency Chart" devised by John C. Parker of the Parker Boiler Co. Our readers may recall a chart of a similar nature, though in somewhat different form, by F. O. Pahmeyer, that appeared in the issue of July 23, 1912. Mr. Parker had previously exhibited at a meeting of the A. S. M. E. the chart printed herewith, which was copyrighted at an earlier date than Mr. Pahmeyer's, although the charts were plotted independently.

Both attain practically the same results and are plotted to coördinate axes. The reader is left to choose that which meets his particular needs.

Selection and Use of Cylinder Lubricants

In these days of close attention to power-plant performances, when many plants are running continuously under test conditions to determine what kind or mixture of coal will evaporate the most water, it is true that too little attention is paid to the selection of steam-engine cylinder lubricant as Mr. Lawrence intimates in his article, in this issue.

Bring up the subject of lubricant selection and the efficiencies of lubricants, especially cylinder oils, among most engineers and the discussion dies at the moment of its birth because so little accurate data are available that few can intelligently discuss the question. Yet it is very important to know if the best lubricant has been selected, price considered, and whether or not the proper quantity is being supplied to the units after the best has been purchased.

Feeding enough oil or lubricant to an engine or pump cylinder to keep the unit from grunting, regardless of all other conditions, cost included, is altogether too common.

It is hoped that the article referred to may induce many engineers to discover what lubricant is best suited for their equipment by determining the number of horsepower-hours per gallon per unit of cost that the lubricant will give under normal conditions of saturated or superheated steam.

When a minimum consumption compatible with good running is discovered for each engine, it should not be difficult to establish and approximately maintain a standard.

It is inconsistent to bewail the loss of a few pounds of coal at, say, three dollars per ton, while ignoring the loss of half a pint of oil at thirty-five cents per gallon.

QUESTIONS BEFORE THE HOUSE

"Keyed" Check Nut

In order to guard against the defect of unlocked nuts on machinery, a millwright having charge of a large mill drilled a hole from the end of the nut, half in the nut and half in the bolt, and filed a "V" in a piece of soft wire which was driven into the hole.

After the introduction of this practice, no trouble was experienced with loose or lost nuts and the possibility of damage to life and machinery was reduced to a minimum.

CHARLES F. SCRIBNER.

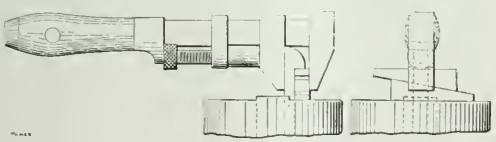
Hartford, Conn.

[This manner of making a nut fast is not new, but mention of it here may serve as a reminder for those who have forgotten it.—EDITOR.]

Removing Solidly Driven Keys

Those who have trouble in removing head-keys from the valve-gears of Corliss engines and other places will find that all trouble may be avoided by adopting the following method of removing the keys.

Place a monkey-wrench over the key as shown, and insert a compound wedge between the jaws of the wrench



SHOWING USE OF WRENCH AND WEDGES FOR REMOVING KEYS

and under the head of the key. By applying a pressure on the end of the wrench and at the same time driving the wedges or cold chisels, whichever is used, the key will slowly and surely come out.

JOHN F. HURST.

Louisville, Ky.

Engine-Driven Fan Increased Combustion

Possibly some reader may be interested in one detail of a steam plant I have been remodeling.

There are two boilers; one 6x18 ft. with 110 three and a half-inch tubes, the other 6 ft. 6 in. by 18 ft. with 118 three and a half-inch tubes. One boiler had a 36-in. smoke flue leading to a chimney 60 ft. high, with a 36-in. square flue. The other boiler had a 36-in. flue leading to a 36-in. steel stack 60 ft. high.

As there were times when the draft was insufficient, I designed an induced-draft arrangement, which works very satisfactorily. As the space was limited the fan and direct-connected engine were placed on a steel-beam platform above and in front of the boilers. The boilers were connected to a U-shaped breeching and the fan inlet was attached at the center of the U. The exhaust flue was connected with the chimney.

The fan engine was fitted with a variable-speed governor, allowing for a 50 per cent. variation in speed. A chronometer valve was placed on the steam pipe to the engine, and the lever of this valve was connected with the damper regulator. In this way the speed of the fan was regulated by the pressure which seldom varies over 2 per cent.

These boilers are in continuous service day and night, and in a test of 25½ hours' duration made recently, evaporated 10.9 lb. of water from and at 212 deg. per lb. of bituminous coal.

Fourteen samples of flue gas were analyzed, showing an average of 11.45 per cent. CO_2. The temperature of the flue gases varied from 370 to 500 deg. The draft gage varied from 1 to $\frac{3}{10}$ in.

S. E. DART.

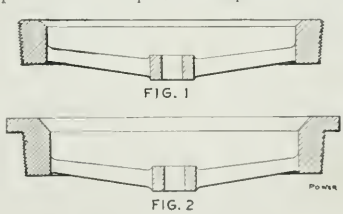
Troy, N. Y.

Leaking Throttle Valve Repaired

The throttle valve on a 1000-hp. cross-compound engine leaked badly, and I was asked to investigate and make repairs. The practice had been, so the attendant stated, to use the starting bar for a lever in an endeavor to tightly close the valve.

Conditions left no reason to doubt that this practice had been indulged in by the attendant.

Fig. 1 shows the seat casting which was without a flange or shoulder, and was probably originally threaded to the pipe, standard taper, viz., $\frac{3}{4}$-in. to the foot, ap



VALVE-SEAT CASTINGS

proximately 8½ in. diameter, and 16 threads per inch. This fine-pitch thread was stripped entirely, allowing the valve seat to be pushed by the disk into the hole in the valve casting, until the guide stem brought up against the back of the valve body, the guide stem being badly bent, showing that a lever had been used to close the valve.

The valve stem proper is 1½ in. in diameter, with a four-pitch square thread, and fitted with an 18-in. diameter wheel. Clearly, then, this made an excellent "jack," using a 12-in. starting bar for a lever, to strip the 16 pitch threads on the seat casting.

Repairs were made by straightening the guide stem

and making a pattern for a new seat, as shown in Fig. 2, with a flange or shoulder ¾ in. larger in diameter than the threaded part and about ⅜ in. thick. This was then threaded to fit the valve casting, so that when screwed down all the way, the shoulder would be set firmly against the iron. Since doing this there has been no trouble in closing the valve tightly by hand.

Columns have been printed on the subject of opening throttle valves wide. More columns should be printed, and read, in an attempt to discourage the practice of using bars and levers on throttle valves, or in fact any kind of valve. When a valve cannot be shut tightly without resorting to this kind of abuse, it is time it was repaired.

H. R. Low.

Moosup, Conn.

Coal Wasted through Ashpit Doors

Recently, in taking charge of 8000 hp. of boilers I found that considerable coal was wasted by falling off of the shovel in firing and going into the ashpit through the ashpit doors. We have 14 boilers, having a total of 60 firedoors and ashpit openings. I found that about 90 shovelfuls of coal were lost each day. To overcome this loss I had screens made of ¼-in. mesh heavy galvanized-iron wire and 1-in. wide by ¼-in. thick iron serving as the material for the frames. We burn No. 2 buckwheat coal and these screens placed in front of the ashpit doors prevent coal from entering the pits and being wasted.

J. T. Fennell.

Philadelphia, Penn.

Measuring Water in Boiler Test

Where neither a feed-water meter nor a weighing tank has been provided on the boiler-feed lines, the arrangement of piping and weighing apparatus shown in the accompanying illustration may be used to ascertain the weight of the water being pumped to the boilers. The weighing barrels and scales, shown in the sketch, can be easily connected up to the piping in any boiler room. The arrangement shown here is in connection with an open feed-water heater and two cross-connected feed pumps.

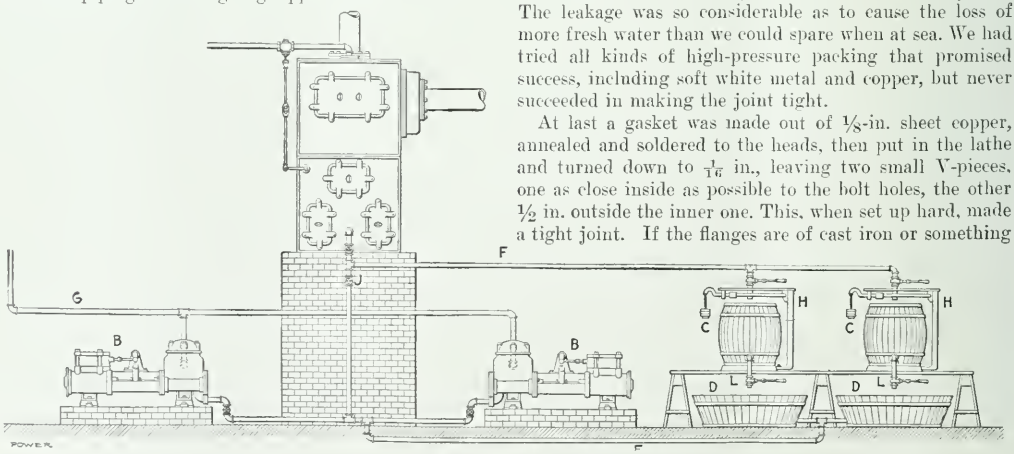
From the feed-water heater discharge to the feed pumps *B* a connection *F* is carried over to the weighing barrels *C*. The inlets from pipe *F* to the barrels are each provided with a valve, preferably a quick-closing valve to permit of the barrels being rapidly refilled.

Barrels *C* are placed on the weighing scales *H*. When valve *J* is shut, the feed water from the heater is diverted to the barrels, and when these are full, the gross weight of each barrel and its water contents is recorded. The valves *L* are then opened and the water emptied into the tubs *D*.

A common suction for the two pumps is connected to the tubs, and the water is pumped from the tubs to the boilers through pipe *G*. When the barrels have emptied, the weight of the empty barrel, with a small amount of water which always remains in the bottom, is obtained, and the difference between this weight and the gross weight of the full barrel represents the weight of the feed water pumped to the boilers.

When a boiler test is being conducted with this weighing apparatus, each barrel is weighed and filled alternately. If the filling and emptying connections to the barrels and tubs are of ample area, say 2 or 2½ in. in diameter, the outfit shown in the sketch will handle an hourly load up to 1000 boiler horsepower.

New York City. James A. McHollan.



Arrangement for Weighing Water in Boiler Test

Copper Ring V-Gasket Stops Leak

The plant of our ship had a capacity of 16,000 hp. We were supplied with two feed-water heaters, 28 in. in diameter, with thirty-two 1⅛-in. studs to keep the heads tight. The back pressure of 8 lb. on the auxiliary exhaust was trapped into a feed tank. The heaters worked nicely, supplying feed water at from 210 to 220 deg. F., but the heads would always leak more or less every trip. The leakage was so considerable as to cause the loss of more fresh water than we could spare when at sea. We had tried all kinds of high-pressure packing that promised success, including soft white metal and copper, but never succeeded in making the joint tight.

At last a gasket was made out of ⅛-in. sheet copper, annealed and soldered to the heads, then put in the lathe and turned down to $\frac{1}{16}$ in., leaving two small V-pieces, one as close inside as possible to the bolt holes, the other ½ in. outside the inner one. This, when set up hard, made a tight joint. If the flanges are of cast iron or something that solder will not adhere to, any other method that will hold the gasket in place will do, as the solder is only used to hold the copper while working it.

G. D. Kramp.

Philadelphia, Penn.

QUESTIONS BEFORE THE HOUSE

Problem in Power-Plant Economics

In regard to L. W. Chadwick's question, in a recent issue, as to power-plant economy, my personal opinion is that it would be far more economical to purchase a new engine than to overload the old one over 50 per cent. If the overload was temporary, say, for a period of four or five years, it might not be economical to purchase a new engine, but as the additional load is permanent and considering the waste of steam with a late cutoff and the increased rate of depreciation, not to mention the danger of a possible accident, due to hazardous engine speed, it would, undoubtedly, be more economical to purchase a new engine.

However, this is a question that can best be answered by the use of operating-cost accounts. If these show a saving by operating at a more efficient load sufficient to cover a fair rate of interest on the cost of a new engine, then buying a new engine would be a good investment. Then, too, it might be cheaper to compound the old engines or to install a condenser. All this depends on conditions in this particular plant, and cannot be decided without a thorough study of the situation. The problem is one that a competent consulting engineer should be employed to investigate and solve.

E. F. Goad.

Decatur, Ill.

Charging for Electric Current

Evidently from writings that have appeared in Power, its readers greatly misunderstand systems of charging for electric current. From the synopsis to W. H. Booth's article in the Apr. 1 issue the editor is in the same position. Indeed, very few not connected with the electric-light business give the matter enough attention to get a clear conception of the problems involved. The principles governing the making of rates for electric service and for the sale of merchandise are radically different; electric current cannot logically be sold like groceries.

Why some features of a system for charging for electric current appear ridiculous when applied to the conduct of a country store is because they do not apply. Central-station men are, no doubt, actuated often by the desire to get business when they adopt a system of charging, but most so called ridiculous systems result from an honest effort to make each customer pay in proportion to what it costs to serve him.

In Mr. Booth's country store each bloater cost the merchant the same, but it is less work to sell a crate to one customer at once than a bloater at a time; therefore, if the merchant charges each customer what it actually costs to serve him, he will charge less per bloater by the crate than one at a time, or, he will sell at the same price each for the bloaters but will charge less for waiting on the customer, when he has only one to wait on instead of many. It takes no longer to pass out a crate than to wrap up a single bloater.

The writer once had to deal with a restaurant keeper, who was offered by the light company the option of two systems of charging, one a sliding scale based on quantity used and the other the so called "readiness-to-serve" schedule. The place was small and kept open late. Therefore it used a great many kilowatt-hours in proportion to the number of lamps. Under the sliding scale the man paid quite a large light bill, but he would not listen to the advantages of the "readiness-to-serve" schedule. As it made his light cost him several dollars a month less, the writer voluntarily billed him by that schedule, but he would roar every month about that "readiness-to-serve" charge, which he did not understand and still he would not listen to explanations. Finally he was sent two bills, one made out on the sliding scale and the other on the hated "readiness-to-serve" schedule, with a letter telling him to pay whichever one he chose. It took no mental effort for him to see that one bill was three dollars less than the other.

In addition to paying for fuel and labor a lighting plant must pay taxes, insurance, depreciation and maintenance before paying interest on the investment. If one were asked to install a plant to supply 720 kw.-hr. per month and to fix the price per kilowatt-hour, how would he proceed? With the data given he would be stumped. He would not know what size plant to install and, therefore, could not estimate what charge to make for labor, fuel, taxes, insurance, depreciation or maintenance. He might be required to be ready to deliver the whole 720 kw.-hr. without a moment's notice at any instant during the month or to deliver only one kilowatt per hour continuously. Obviously the price per kilowatt-hour must depend on the factor of "readiness-to-serve" which is simply a short way of saying, taxes, insurance, depreciation, maintenance, interest on investment, etc.

Take a concrete case. A plant was desired for a small town which has no prospect for growth. To be economical the plant must be just large enough and an estimate made of the probable demand of each customer. It was concluded that 25 kw. would be large enough and that 100 customers would be secured. Some of these would use several lights for a short time each evening and some only a few but for longer periods. The franchise required that the company be prepared to furnish service to all who might apply for it. The completed plant cost about $8000. In effect, a part of this investment was made for each of the 100 customers and this portion is nearly directly proportional to the most current the customer would demand when the load on the plant is at the peak. Some of the investment is made when the customer is connected, but most of it when the plant is installed. But to all intents and purposes the money is tied up for that particular customer's benefit and the company is compelled by law to tie up most of this money because the company must serve all who apply or forfeit its right to do business.

Mr. Booth's merchant is under no obligation to supply all the bloaters that might chance to be called for. More-

over, if his stock of bloaters becomes exhausted, he can replenish it quickly. When more service is demanded than a central station can furnish, its capacity is not easily increased.

In the case under consideration the rate per kilowatt-hour was fixed at 15c., because it was thought that would be all the traffic would bear, but to yield a reasonable income on the investment the rate would probably have been higher. A minimum charge of $1.50 per month was made. Suppose a customer uses 10 kw.-hr. a month; he would just use his minimum, and suppose he uses this amount by burning his lamps a short time each evening over the peak, or when the load on the plant is the highest, and suppose the $1.50 is a fair price for the service rendered and paid for this customer's share of the investment. Again, suppose this customer, by burning the same lamps more hours, should use twice as many kilowatt-hours, should he pay twice as much? By no means. He has already paid his share of the investment and now he should only have to pay for what the additional current cost plus a fair profit. At this little plant the additional current can be generated at the cost of 10 lb. of coal per kilowatt-hour or about 0.014c. per kw.-hr. Is it logical to charge the customer 15c. for what only costs about 1½c.? Central stations do not charge the same for every individual kilowatt-hour sold, because each one does not cost the same.

Suppose the customer uses twice the number of kilowatt-hours by burning twice the number of lamps for the same length of time. Then his service will cost the company nearly twice as much and he should pay about twice as much. The plant mentioned does not give day service, but only runs from dusk until dawn. A certain customer has lamps requiring 1½ kw. and averages about 80 kw.-hr. per month, for which he pays the 15c. rate. If this customer used his lamps all night every night he would use about 540 kw.-hr. per month. The additional 460 kw.-hr. would require the burning of only about 2.3 tons more coal and but very little other expense. Therefore, the 460 kw.-hr. would cost the light company less than the first 80. Would there be any reason in charging the same rate?

In the foregoing the writer has not attempted to take into account all the factors involved but only to show why the same system would not apply to electric service and a country store. In devising a system of charging for electric service, the above and other factors must be considered, and the problem becomes very complex. Its complexity accounts for many of the seemingly ridiculous systems in use, and among the difficulties in the way of a simple solution of the problem, one of the greatest is the public's steady refusal to try to understand the matter. It must also be admitted that many persons engaged in the manufacture and sale of electricity have never given the question much study.

G. E. Miles.

La Jara, Colo.

Electric Elevator Questions and Answers

In Mr. Waldron's catechism, published in the issue of May 13, are some answers and explanations which might have been more complete. In his answer to the first question where he speaks of the possibility of the car having run down so far that the counterweights have opened the hatch-limit switch (which is contrary to my experience, the car usually operating the limit switches), he advises working the car up by the use of spanner wrenches.

By holding the potential switch in place, the car may be moved from the board or from the car. This is perfectly safe, and surely much easier than his method. An operator will often allow the car to run down too far with a load, before shutting off the power, thus permitting the car to reach the limit switch and the car is then moved as stated. His answer to the question: "What causes the car to make a solid stop?" is rather puzzling to me. Why should the top shoe be moved rather than the bottom shoe, when the car stops with a jerk on the up motion? Do not the brake shoes set the same for both motions? What would Mr. Waldron do where the brake shoes are set on each side of the brake pulley, and not on the top and bottom?

Relative to his statements about getting a car in service after the safety device has operated, assuring the passengers of perfect safety, and taking up the slack in the hoisting cable is all right, but I do not see how he is going to slacken off the safety clutch before resetting the centrifugal governor on the top of the hatch. He does not specify the particular type of safety he had in mind, but from answers to other questions, judge it is one of those which, when the car is in normal operation, the slack portion of the governor or rather the safety-clutch cable is wound on a small drum, under the floor of the car. When the centrifugal governor, at the top of the hatch, trips (which it can only do when the car is on the down trip), the governor clutch grips the governor cable, pulls it out of the clutch on top of the car and as the car continues its downward course, the cable on the safety drum is pulled off, thus driving the drum around and setting the clutches on the guide rails.

Now, if that clutch will hold a heavy car, and its load, how can a small socket wrench move it until the governor is reset? The governor clutch should be reset before attempting to wind up the drum.

Mr. Waldron might have added to his answer regarding the wear of cables, that the drum-counterweight cables are first to go, owing to the fact that in the single-drum machine located in the basement, the drum-counterweight cables have to make an S-bend over the drum and traveling sheave, where the lifting cables have only a U-bend, thus making the life of the drum-counterweight cables shorter by 30 per cent. than the lifting cables.

Brooklyn, N. Y. W. H. Pyatt.

Comments on Flue-Gas Analysis

Regarding the flue-gas analyses readings submitted by F. A. Lowe, in Power for May 20, it is difficult to comment intelligently on account of the lack of information regarding the coal burned and the apparatus used for sampling and analyzing the gases, etc., but a knowledge of certain general principles may enable him to locate and correct his troubles.

The average totals, that is, the sum of CO_2, CO and O appear high, especially for the percentages of CO_2 obtained, unless the fuel was largely anthracite. With average bituminous coals entering the New England market the amount of hydrogen present in the coal and available

for combination with the oxygen of the air supplied for combustion is sufficient to lower the total of CO_2, CO and O (If CO is not present in too large a quantity, when it causes an appreciable increase in the totals) by about one-sixth of the percentage of CO_2 found, below the value of 20.9, which it would have if the fuel were pure carbon. If a gas analysis shows 15 per cent. CO_2 when burning New River coal, it is to be expected that the sum of CO_2, O and CO (if not over 1 per cent. of CO is present) will be rather close to

$$20.9 - \tfrac{1}{6} \times 15 = 18.4 \textit{ per cent.}$$

The cause of high totals is too large capillary tubes, either in the manifold of an Orsat or in the connections of other forms of apparatus. For example, the volume of the most common form of Orsat burette is 100 c.c. Supposing that that part of the capillary tube from the upper mark on the burette to the stop-cock of the CO_2 pipette contains 1 c.c., then the volume of gas analyzed for CO_2 will be 101 c.c., and if the gas actually contains 15 per cent. CO_2 the decrease in volume will be 15.15 c.c. and will read as 15.15 per cent. CO_2 in the burette. Similarly if the volume of the manifold up to the stop-cock of the oxygen pipette is 2 c.c. and the true percentage of CO_2 and oxygen is 18.4 per cent., the decrease in volume will be 18.77 c.c. and will read on the burette as 18.77 or an increase of nearly 0.4 per cent. over the true total.

If, as some operators recommend, the capillary is filled with water in expelling the last of the old sample and the branches to the pipettes become filled with water, the effect of the large capillary is even more pronounced, as during analysis this water is forced into the pipettes and its place must be taken by gas from the sample, indicating a greater absorption than has actually taken place, equal to the volume of the water contained in the capillary branches. But under whatever conditions the analyses were made I would reject the first analysis in the table presented by Mr. Lowe as the total of CO_2, CO and O equals 22 per cent., whereas if the fuel were pure carbon it could not properly exceed 21.5 per cent. even with this percentage of CO.

Negative readings of CO may be due to three causes: The first and most usual one is a change in temperature of the sample and apparatus during analysis. If the temperature increases the sample expands as the atmospheric pressure at which it is measured remains constant and the result is a lower reading after absorption in the CO pipette than before. Comparatively slight temperature changes will produce this effect. For instance, since the volumes of gases at constant pressure are proportional to their absolute temperatures, to produce the —0.2 CO reading shown in the fifth analysis at 11 o'clock, if the gas sample was at a temperature of 70 deg. F., it would require an increase in temperature of

$$\frac{0.2}{79.4}(70 + 461) = 2.34 \textit{ deg. F.}$$

This can easily occur unless a water-jacketed burette is used and the apparatus is kept out of drafts. The best way to detect this is by a small thermometer suspended in the burette jacket, but if on checking the CO_2 or O absorption, there is a continued apparent increase or decrease of one- or two-tenths per cent., a change in temperature is to be suspected and indications of small quantities of CO_2 should be given little weight.

Occasionally if the cuprous chloride solution is too strongly acid and the apparatus is used in a rather warm place, hydrochloric-acid gas will be given off and increase the volume of the sample, producing a negative CO effect. This is easily detected by passing the gas into the CO_2 pipette where the caustic potash will immediately absorb the hydrochloric-acid gas and give the true reading. This is also useful when ammoniacal cuprous chloride is used, up to the saturation point of the liquid in the CO_2 and O pipettes with ammonia gas. A better way is to keep the water in the burette slightly acid with sulphuric acid and use a little phenolphthalein to show that it remains so.

A third and less usual cause is in cases where much CO is present in the gases being analyzed, the cuprous chloride solution becomes so nearly saturated with CO that, while it will still absorb some CO from gas containing considerable CO, it will give up CO to a gas containing little or no CO, and in this way produce a negative reading, such as shown in Mr. Lowe's tables. This condition can be detected by analyzing a sample of air, in which case the amount of CO given up will be a measure of the amount going through the analysis undetected and the analyses can be corrected accordingly.

In fact, if one has a suspicion that the apparatus is not working just right it is a very convenient check to analyze a sample of air, for by comparing the results obtained with the true values of 20.9 per cent. oxygen and 79.1 nitrogen it is usually possible to tell what is wrong.

Newton Highlands, Mass. H. D. Fisher.

Countersunk Rivets on Boilers

In the issue of Apr. 1, under Inquiries of General Interest, someone asked if it was allowable to use countersunk nearly flush with the sheet.

I have worked in locomotive-repair shops several years and where the rivets are inside the firebox of locomotive boilers the use of countersunk rivets is quite extensive; in fact, on some, if not all, railroads the rivets inside the firebox are countersunk altogether, more especially along the side sheets and fine sheets. The mud-ring rivets are below the fire and they are not always countersunk, but quite frequently are.

It seems that the intense heat inside the firebox of this class of boiler burns off the heads if they are not countersunk nearly flush with the sheet.

In putting in a heavy flue sheet in the firebox the edge of the flange is generally scraped down quite a bit for the same reason, for if it is left very thick the heat injures it and makes it crack and leak all the more quickly.

Here is an incident which happened recently that may be of some interest: The boiler was being repaired and quite a few new stay-bolts had been put in the side sheet. When the boiler makers started to hammer up the stay-bolts the weather was pretty cold and the steel was cold. When they started to hammer the bolts the sheet cracked along a line between five stay-bolts, a length of about 22 in., making a new side sheet in the firebox necessary.

On examining the steel where it was cracked it had the frosted appearance of tempered tool steel when broken. It seems that the intense heat and strains on a firebox on a locomotive boiler tend to crystalize the metal and make it very brittle, as I have known of several such cases.

Livingston, Mont. Harold J. Wilkinson.

INQUIRIES OF GENERAL INTEREST

Lost Motion in Pump Valve Stem—What will be the effect of taking the lost motion out of the valve stem of a duplex pump?

F. M. S.

It will make the valve operate more promptly and result in shortening the stroke of the pump.

Adding Lap to Pump Valve—What would be the effect of adding lap to the steam valve of a duplex pump?

F. M. S.

It would have the effect of cutting off the steam before the end of the stroke causing the steam to act expansively for a short time as in an engine, and it would also delay the beginning of the stroke.

Cast-Iron Steam Pipe—Is cast iron suitable for underground steam piping?

J. P. S.

Cast iron has the advantage over wrought iron or steel of resisting corrosion better and hence is preferable for use underground, but it is a poor material for carrying steam of any pressure higher than 10 lb. per sq.in., because of the uncertainty of its strength and its behavior in expanding and contracting when subjected to variations in temperature.

Meaning of Name-Plate—The name-plate of a Worthington duplex steam pump patented Apr. 4, 1899, has the following size rating:

$$\frac{190 \times 216 \times 152}{7\frac{1}{2} \times 8\frac{1}{2} \times 6}$$

What does it mean?

J. E. M.

The upper figures are the metric equivalents of the lower ones. The pump has a 7½-in. (190 mm.) steam cylinder, 8½-in. (216-mm.) pump cylinder, and 6-in. (152-mm.) stroke.

Heating Water Electrically—What current and what size wire and how much of the wire would be required to raise the temperature of one gallon of water 10 deg. in 5 min.?

E. H.

From a table in Foster's Electrical Engineers' Pocketbook it is found that it will take 325 watts. At 110 volts this would mean approximately three amperes and a resistance of 36 ohms. A No. 20 iron wire has a resistance of one ohm for every $8\frac{1}{2}$ ft. Therefore,

$$8\frac{1}{2} \times 36 = 306 \text{ ft.}$$

of No. 20 wire would be required.

Double Ports in Duplex Pumps—Why is a duplex steam pump double-ported?

J. N.

To give separate passages for intake and exhaust of steam. The latter are not so near the ends of the cylinder as the steam ports and when the piston covers them no more steam can escape so that the piston is brought to rest without shock by the "cushioning on the exhaust." The steam thus imprisoned fills the clearance space back to the valve seat and when the valve opens the steam port at the beginning of the next stroke the clearance space does not require filling with live steam.

Life of Condenser Tubes—What is considered a reasonable length of life for condenser tubes using brackish water?

A. S. L.

The life will depend on local conditions. In one plant in the vicinity of New York where the condensing water is contaminated with sewage, the tubes last on an average of four years. At another plant where the water is acid the tubes have to be renewed on an average of every two and a half or three years. Another large New York plant reports a tube life of three years. All of these plants use aluminum-bronze condenser tubes, preferring them to those made of the admiralty composition.

Reversing Engine Rotation—How is the direction of rotation of a slide-valve engine reversed?

W. B. B.

Turn the engine over until the crosshead is at one end of its stroke and block the flywheel. The center of the eccentric will then be above or below the center of the shaft. Observe how far it is to one side or the other of the center and after loosening the eccentric revolve it around the shaft until it is the same distance from the center as before, but on the opposite side. Then remove the steam-chest cover and adjust the valve stem so the valve has the same lap over the steam port at each end.

Riding Cutoff—What are the advantages of having an adjustable riding cutoff on the low-pressure steam end of a cross-compound compressor?

R. R.

The adjustable riding cutoff equalizes or varies the relative amount of load carried by the high- and low-pressure cylinders, lengthening the cutoff on the low-pressure cylinder having the effect of reducing the proportion of power developed in the low-pressure cylinder, while shortening the cutoff in that cylinder increases the back pressure on the high-pressure cylinder and reduces the proportion of power developed in the high-pressure cylinder. A full explanation of the effect of changing the point of cutoff is given in the article "Shorter Cutoff, Greater Load," by F. R. Low, in "Power," Aug. 6, 1912, page 180.

Strain on Stay-Bolt—The outside nuts on a boiler stay-bolt are tightened until the strain is 8000 lb. in the body of the bolt. Then the inside nuts are tightened until the strain in the threaded part between the nuts is 2400 lb. Finally the boiler is put under 100-lb. pressure. What is the total load on the stay if each stay supports 100 sq.in.?

E. J. K.

The strain on the body of the bolt due to the boiler pressure would be

$$100 \times 100 = 10{,}000 \text{ lb.}$$

The initial strain being 8000 lb. due to the outside nuts, the body of the bolt will be under 18,000-lb. strain. The strain due to the inside nuts reduces no strains anywhere, but puts an added strain on the threaded parts of the bolt making the total strain at those points 20,400 lb.

Pump Capacity—How much water per hour will a duplex steam pump handle having a 6-in. steam cylinder, 4-in. water cylinder and 6-in. stroke, when making 75 r.p.m.?

W. H.

The cross-sectional area of the water cylinder, neglecting the area of the rod, is

$$4 \times 4 \times 0.7854 = 12.566 \text{ sq.in.}$$

The displacement for one 6-in. stroke would be

$$12.566 \times 6 = 75.396 \text{ cu.in.}$$

and for 150 (2 × 75 r.p.m.) strokes and two cylinders (the pump being duplex) would be

$$75.396 \times 150 \times 2 = 22{,}618.8 \text{ cu.in. per min.}$$

or

$$\frac{22\,618.8}{231} = 97.917 \text{ gal. per min.}$$

or

$$97.917 \times 60 = 5875.02 \text{ gal. per hr.}$$

These figures do not take slippage into account.

Vacuum at High Altitude—How many inches of vacuum is it possible to obtain at an altitude of 10,500 ft.?

R. R.

At sea level the atmospheric pressure is 14.7 lb. per sq.in. At one mile, or 5280 ft. above sea level it is 12.02 lb. and at two miles, or 10,560 ft., it is 9.8 lb. Roughly the pressure decreases ½ lb. per 1000 ft. of ascent. For an altitude of 10,500 ft. (which is 10,560 — 10,500 = 60 ft. less than 2 miles) the pressure may be taken to be

$$\frac{60}{1000} \text{ of } 0.5 = 0.03 \text{ lb.}$$

less than 9.8 lb. or 9.77 lb. per sq.in. As 2.0355 in. of mercury is balanced by 1 lb. of pressure, then with a perfect vacuum, an atmospheric pressure of 9.77 lb. would balance a column of mercury

$$9.77 \times 2.0355 = 19.887 \text{ in.}$$

and with good condensing apparatus it should be possible to maintain a vacuum of 19 in.

ENGINEERS' STUDY COURSE

Estimating Heat Value of Fuel

The heat value of a fuel is estimated either by actually burning a small sample and measuring the heat given off or by calculation based on either the ultimate or the proximate analysis. The first is the more accurate method, but as the cost of the required apparatus is rather high, and as it is not important for everyday work to know the exact heat value of every lot of coal received, we will pay most attention to the second method and pass over the first after giving a brief description in order that you may be familiar with it in a general way.

Coal Calorimeter

The sample burned is as carefully selected and prepared as the sample used for the proximate analysis, and its weight is usually the same, 1 gram. It is burned in a device called a calorimeter—a name derived from the

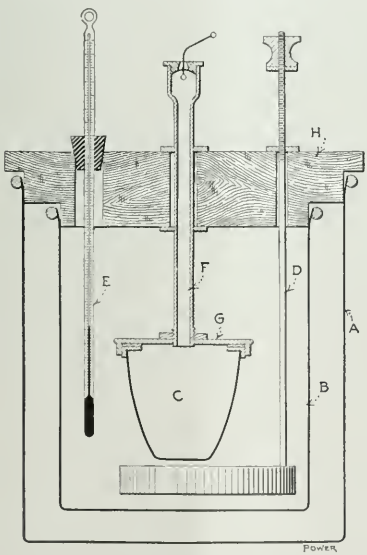


Fig. 1. Simple Form of Coal Calorimeter

words caloric, meaning heat, and meter, meaning measurer.

Fig. 1 illustrates a simple form of the commonest type of coal calorimeter. The bomb or crucible C of iron or steel and lined with some material which is not affected by the products of combustion, contains the sample of coal to be tested, and is suspended in the water chamber B as shown. This water chamber is surrounded by the casing A to reduce error due to radiation. The stem F is hollow and closed off at the upper end by a valve. The wooden lid H is tight fitting. To load the bomb C it is taken out and unscrewed from the cap G. The sample of coal, thoroughly mixed with the proper amount of some chemical which gives up oxygen when heated (usually sodium peroxide) is put into the bomb and the latter is again screwed into place. A quantity of water, which has been exactly measured, is then put into B, and when the lid H is again fixed in place, the calorimeter is ready for the test. The water is stirred for a few minutes with the paddle D until the thermometer E shows that the temperature has ceased changing. Then the valve at the top of the stem F is opened, a small piece of red-hot nickel wire is dropped in and the valve quickly closed again.

Rapid and complete combustion takes place due to the liberation of the oxygen from the chemical mixed with the coal. The heat-laden products of combustion are all trapped in the bomb and hence must give up their heat to the surrounding water, which is again stirred for several minutes to hasten the transfer and to maintain uniformity. The rise in the temperature of the water is carefully noted, the thermometer being graduated to read in small fractions of a degree.

Knowing the weight of the water and the rise in temperature, the number of heat units generated by the sample can easily be calculated by multiplying these two factors together, and the heat value of a pound of fuel can then be found by multiplying by a constant, which takes into account the ratio of weights and other factors involved.

Heat Value by Calculation

As has been pointed out, the combustion of a given element always results in the generation of a fixed amount of heat. Thus, when a pound of pure carbon burns completely (forming CO_2) 14,600 B.t.u. is produced. When 2 lb. is burned, 29,200 B.t.u. is generated, and so on. Consequently, the heat value of carbon is said to be 14,600 B.t.u.—which means 14,600 B.t.u. per lb., as the pound is the unit of weight almost universally used in this country.

When a pound of pure carbon burns incompletely (forming CO), only 4450 B.t.u. is produced. But if, in turn, the resulting $2\frac{3}{4}$ lb. of CO, which is a combustible gas, is burned, 10,150 additional B.t.u. is liberated, making the total heat produced equal to 14,600 B.t.u., just the same as though the pound of carbon had burned completely (to CO_2) in the first place. Hence, the heat value of CO is

$$\frac{10{,}150}{2.333} = 4350 \text{ } B.t.u. \text{ } per \text{ } lb.$$

The heat value of pure hydrogen is 62,000 B.t.u. per lb.

These heat values for carbon and hydrogen were established by experiment and hence probably are not absolutely exact. In fact, some authorities give values for carbon as low as 14,220, and as high as 14,647, and for hydrogen as low as 61,816 and as high as 62,032, but as the ones given (14,600 and 62,000) are the most widely accepted and used, it is best to accept them for use in our work.

The heat value of sulphur, the only other heat-producing element in the common fuels, is 4050 B.t.u. per lb. While this fact is interesting, it is not important in practical work, because in addition to the heat value of the sulphur itself being low, the percentage of sulphur in the average fuel is also low; besides, the sulphur may not be pure and hence may have no heat value whatever. Thus the amount of heat due to the sulphur is very small compared with that given up by the two main elements, carbon and hydrogen.

To estimate the heat value of a pound of fuel containing both carbon and hydrogen, simply multiply the percentage of total carbon in the fuel (expressed as a decimal) by 14,600, the percentage of available hydrogen (also expressed as a decimal) by 62,000 and add the results together.

To illustrate, assume we wish to estimate the heat value of a coal with this analysis: Carbon, 68.12 per cent; hydrogen, 4.98 per cent.; oxygen, 7.42 per cent.; nitrogen, 1.98 per cent.; sulphur, 4.54 per cent.; ash, 12.96 per cent.

The heat due to the carbon is

$$0.6812 \times 14{,}600 = 9945.5 \ B.t.u.$$

The available hydrogen equals

$$0.0498 - \frac{0.0742}{8} = 0.0405$$

and this, multiplied by the heat value of hydrogen,

$$0.0405 \times 62{,}000 = 2511 \ B.t.u.,$$

the heat due to the hydrogen in the coal. The sum of these two quantities is

$$9945.5 + 2511 = 12{,}456.5 \ B.t.u.$$

the heat value of the coal.

Heat Value by Formula

The foregoing method can be expressed in a formula as follows:

$$C \times 14{,}600 + \left(H - \frac{O}{8}\right) 62{,}000 = B.t.u. \ per \ lb.$$

where

C = Decimal part by weight of carbon in the fuel;
H = Decimal part by weight of hydrogen in the fuel;
O = Decimal part by weight of oxygen in the fuel.

To apply this formula to another example, assume a coal with this analysis: Carbon, 65.23 per cent.; hydrogen, 4.95 per cent.; ogygen, 14.85 per cent.; nitrogen, 1.66 per cent.; sulphur, 2.10 per cent.; ash, 11.21 per cent. Substituting in the formula, we have

$$0.6523 \times 14{,}600 + \left(0.0495 - \frac{0.1485}{8}\right) 62{,}000$$

$$= 11{,}439 \ B.t.u.$$

The foregoing method or formula may be used for any other kind of fuel or for oil, wood, gas, etc. In dealing with gas, however, care must be used that volumes and weights are not confused to produce error. A common method of stating the heat value of a fuel gas is in B.t.u. per cubic foot or per 1000 cu.ft. In such cases the temperature and pressure of the gas must also be specified because these influence the volume greatly. The temperatures most frequently taken are 32 and 60 deg. F., and the pressure, 14.7 lb., absolute.

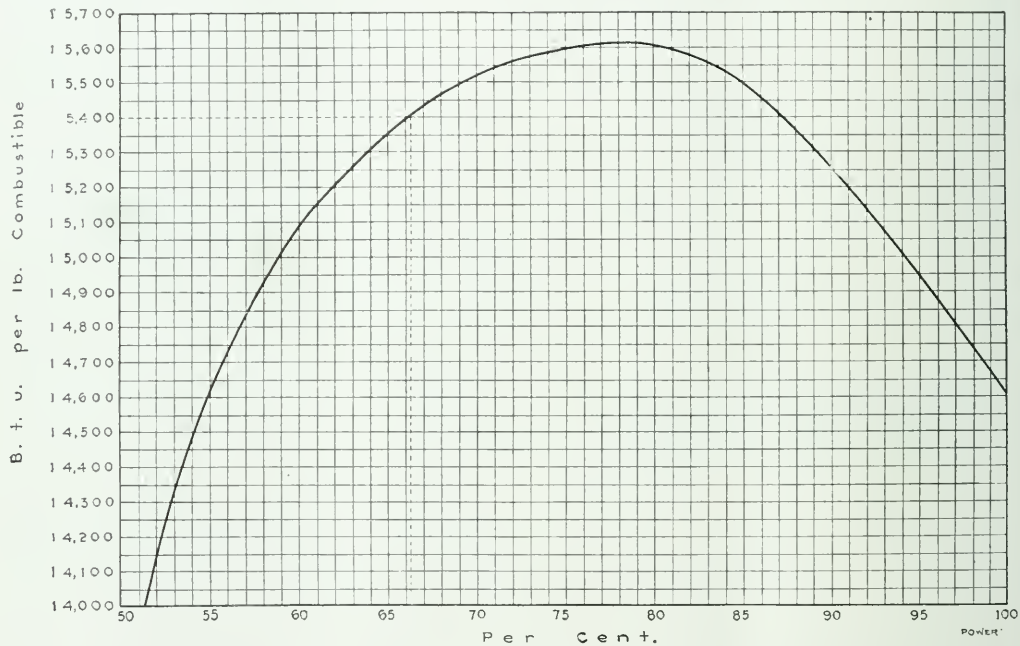


Fig. 2. Diagram for Estimating Heat Value of Coal from Proximate Analysis

Heat Value from Proximate Analysis

The proximate analysis of coal does not give the percentage of hydrogen, the percentage of oxygen nor the

percentage of total carbon. It does give the percentage of fixed carbon, but in addition to this the fuel contains some carbon which forms part of the volatile matter and the amount or percentage of this volatile carbon cannot be found except by the ultimate analysis. Hence, the formula just given is of use only in those few cases where the ultimate analysis is available, so that other methods will mostly have to be used in our work.

Some relation exists between the percentage of fixed carbon in the combustible matter of coal and the heat value of the combustible matter. To illustrate, if the combustible matter of a given coal consists of, say, 60 per cent. fixed carbon and the other 40 per cent. volatile matter, it is probable that the heat value of a pound of such combustible matter will be found to be about 15,080 B.t.u. This does not apply closely to all coals, but it applies closely enough to most coals to be useful in the absence of a better or more accurate method of estimation that can be used with the proximate analysis.

Fig. 2 is based on this fact. This chart was constructed from over 300 analyses, representing coal found in 27 states and territories, made by the United States Government and published in numerous bulletins. It is almost exactly correct for a limited number of cases, reasonably near correct (probably within 3 per cent.) for a large number of cases and quite far from correct in a few cases. The curve is most uniformly accurate for coals which have combustible matter containing from 64 to 90 per cent. fixed carbon. Where the fixed carbon runs less than 64 per cent. the curve may, in a few cases, err as much as 7 per cent.

Application of Chart

To estimate the heat value of a coal with a given proximate analysis, add together the percentage of fixed carbon and the percentage of volatile matter in the coal; divide this sum into the percentage of fixed carbon and multiply by 100. This gives the percentage of fixed carbon in the combustible matter. Locate this percentage at the foot of the chart, extend your pencil straight up until you strike the curve, then extend it to the nearest (left or right) margin in a straight horizontal line and read off the B.t.u. per pound of combustible. Multiply the B.t.u. thus found by the sum of the percentage of fixed carbon and volatile matter in the coal as shown by the proximate analysis, and the answer, divided by 100, gives the B.t.u. per pound of coal.

To illustrate with an actual example, assume a coal with this proximate analysis: Moisture, 5.12 per cent.; volatile matter, 27.25 per cent.; fixed carbon, 53.38 per cent.; ash, 14.25 per cent. Adding together the percentage of fixed carbon and the percentage of volatile matter,

$$53.38 + 27.25 = 80.63.$$

Dividing this into the fixed carbon, we have

$$53.38 \div 80.63 = 0.662,$$

which, multiplied by 100, gives 66.2 per cent. fixed carbon in the combustible. Referring to the base line of the chart, find the 66 per cent. line and judge a point 0.2, or $\frac{1}{5}$, of the distance to the next line beyond. Trace an imaginary vertical line (this line is shown dotted on the chart) up from this point to the curve and then horizontally to the left margin. It strikes exactly the 15,100-B.t.u. line. Then, 15,100 B.t.u. may be taken as the heat value of a pound of combustible matter such as found in the coal given in the example.

Now, if the coal was all combustible and had no moisture nor ash, the heat value per pound of coal would be identical with the heat value per pound of combustible. But only 80.63 per cent. of the coal is combustible, and hence the heat value of a pound of coal is equal to only 80.63 per cent. of the heat value of a pound of combustible. Thus, the heat value of the coal is

$$15{,}400 \times 80.63 \div 100 = 12{,}417 \ B.t.u.$$

Exercise Problems

What is the heat value of a coal with the following ultimate analysis: Carbon, 63.65 per cent.; hydrogen, 5.26 per cent.; oxygen, 10.12 per cent.; nitrogen, 1.59 per cent.; sulphur, 5.03 per cent.; ash, 14.35 per cent.?

Estimate the heat value of a coal which has this proximate analysis: Moisture, 1.36 per cent.; volatile matter, 35.51 per cent.; fixed carbon, 50.06 per cent.; ash, 13.07 per cent.

NEW PUBLICATIONS

BERECHNUNG, ENTWURF & BETRIEB RATIONELLER RESSELAUHAGEN (Calculation, Design and Operation of Rational Boiler Plants). By Max Gensch. Published by Julius Springer, Berlin, Germany. Cloth, 6x9 in.; 207 pages; 95 figures. Price, $1.50.

Although steam-boiler design has been developing for so many years much improvement can still be made in the various parts of a boiler plant. The object of this book is to show how such improvements can be accomplished, if the designer will accept better information about the processes involved in steam production. In his preface, the author points out why he contends we have not advanced far from the first stage of boiler design, although marked improvements have been made in economy. This, he maintains, is clearly perceived if we look at the present status of boiler design and the every-day specification of their form, etc. We can expect to make considerable progress only through a careful development of the theories involved.

This book is, therefore, highly theoretical and can only be used by persons possessing a thorough knowledge of higher mathematics. It is arranged very concisely and clearly without going far into details of existing boiler types. The subject is treated rather from a general point of view.

In the first chapter, "The Furnace," the author makes an exhaustive study of all factors involved in building an efficient furnace. The questions of fuel, air supply, flue gases, radiation, etc., are carefully analyzed and practical examples help to explain the complicated formulas. With like carefulness the heating surface is treated in another chapter. The importance of rightly proportioning the heating surface is shown and the development of steam, the capacity of the heating surface, water circulation, etc., are exhaustively treated. A special chapter is devoted to the draft, since the economy of a boiler plant is largely dependent on a careful dimensioning of the flue and stack. The contents of this chapter ought to be of great value to the designer. Formulas are given by means of which good results can be obtained. Practical examples show the usefulness of these formulas. The final chapter is devoted to the general erection of boiler plants. It is very important, as it deals with the problems involved in selecting boilers, furnaces, economizers and superheaters. Space is also devoted to controlling devices, such as those for determining the daily coal consumption, flue-gas analyzing apparatus, etc.

This book should prove of great use not only to the constructor and student, but also to the user of boiler plants.

In erecting the 80-ft. sheet-iron smokestack at the new boiler plant of the Belle-Vernon-Mapes Dairy Co., Cleveland, Ohio, a three-ton motor truck was made to serve as a hoisting engine. The stack weighed nearly 4500 lb. and had to be elevated to a masonry foundation 12 ft. above the ground surface. A guyed mast was set up alongside the base of the stack; a cable, made fast to the stack, was carried through a pulley at the masthead, down to a second pulley near the ground and thence to the motor truck. The truck then was backed away from the mast and the stack hoisted until it could be swung around and lowered into position on its foundation. The operation consumed only a few minutes.

Engine-Cylinder Lubrication

By Willis Lawrence

SYNOPSIS—It is pointed out that a high-priced oil is not necessarily the best oil for steam-engine cylinder lubrication, also that the moisture content of the steam, a most important factor in selecting a good oil, is too often a matter of mere guesswork. Graphite combined with oil proves a good lubricant for engine cylinders.

When supplies are purchased for the steam plant, some known standard of quality is employed to ascertain the plant value of the supply, or the composition of the material is learned and the known value of the constituents give to the supply its value. In the buying of coal the British thermal units, ash, carbon, etc., fix the value. The value of metals is governed by their composition:

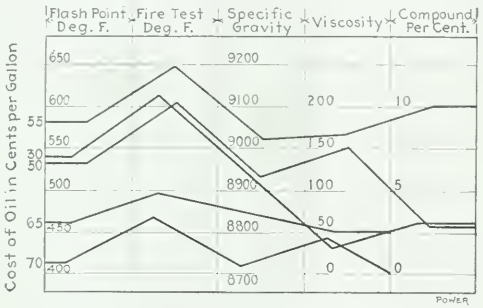


Fig. 1. Test Results of Various-Priced Cylinder Oils

textiles by their fibers, weave, etc., but in the selection of a cylinder lubricant such methods are rarely employed, although the selection of a suitable oil, owing to its influence on the maintenance and operating costs, demands more critical attention than is usual in power-plant practice.

A common occurrence when trouble appears in the form of scored cylinders and valves, is to hold the oil responsible for the damage. After the necessary repairs are made and possibly the mechanical cause of the trouble removed, another oil is substituted with very satisfactory results. Both oils may have come from the same field, had the same composition and physical properties, in fact, be the same oil, but from barrels with different trade names, and the admiration for the second, together with the condemnation of the first, would be unjustified. Most engineers do not compare the physical properties of the oils to learn which one possesses the most desirable constituents for his particular needs, but is satisfied to continue with the oil which operates the engine without any outward appearance of trouble.

This condition works a hardship on the oil seller as well as on the oil user, as it does not place the buying of oil on a safe competitive basis. The honest salesman who is anxious to submit his wares for competition based upon their composition and characteristics is often shut out, while inferior goods at high prices are admitted to the plant, working an injustice to the producer and consumer.

Should an engineer for any cause be compelled to change the cylinder oil through its failure to give desired results, he would naturally look for a better oil. This might mean a more suitable oil for his requirements at a lower cost, or different composition at the same cost. Not knowing the values of the different constituents he will generally buy a higher-priced oil with the result that he may possibly get an oil inferior to that which he was using, judged from the point of plant valve.

Fig. 1 shows curves plotted from analyses of different oils ranging in price from 30 to 70c. Considering that oil having the higher flash and fire test with the proper compounding as being the most suitable for steam-cylinder lubrication, we are forced to the conclusion that the plant values of these oils are in inverse proportion to their prices. The lower lubricating values represented by the curves are for gas-engine cylinder lubrication, which demands a more fluid oil with absence of carbon-producing matter. They usually represent an earlier stage of distillation and probably cost more to produce, due to the filtering process, but the increased cost of production does not seem to be sufficient to justify the higher prices quoted. It will be seen that had the engineer selected an expensive oil he would have undoubtedly received a lubricant entirely unsuitable for the steam cylinder. We must select an oil free from tar and similar

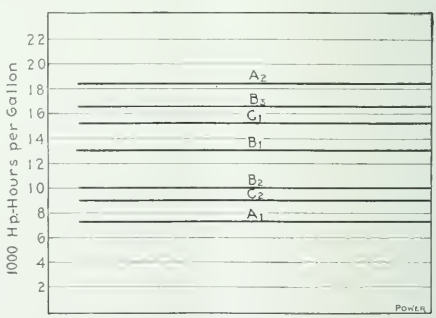


Fig. 2. Results of Tests of Cylinder Oils

bases, which forces us to the Pennsylvania crude oil. This product is almost entirely free from these heavy carbons and has a paraffin base. When the refinement is carried to the point where the oil burns at 600 or 650 deg. F., and contains sufficient acidless tallow to form an emulsion with the moisture in the steam, we have the standard high-grade steam-cylinder oil. It will be seen that the influence of the oilman is limited, and is usually confined to compounding the oil to meet the moisture conditions. In this he is compelled to rely upon the engineer's report, who in turn is usually without the necessary means to accurately determine the amount and he is compelled to guess at the proportion. If the salesman accepts the report as being correct, he compounds the oil accordingly. It will be seen, then, that one of the most important constituents is proportioned by guess, and this condition explains the trouble sometimes encountered in securing the proper oil to meet the plant requirements.

The "old hand" at the business, when trouble is re-

ported at a certain plant, rushes to it with an oil high in tallow, often as much as 12 per cent. and invariably produces an improvement in conditions, and after securing the business proceeds to lower the animal matter to a reasonable amount. The foregoing conditions are illustrated in the curve, Fig. 2, where three oil companies competing for the plant's business put forth their best efforts to secure the highest efficiency for their oils.

A on his first attempt secured 7500 hp.-hr. per gal. followed by 18,500 hp.-hr. on the second trial. B's first trial resulted in 13,000 hp.-hr., the second in 10,000 hp.-hr. The third trial went to 16,500 hp.-hr., while C's efforts secured 15,500 and 9000 hp.-hr. respectively. It is obvious that if their products had been compounded with a reasonable degree of certainty the results would have been more certain.

After experimenting with similar conditions the writer is confident that graphite properly administered would have given all the oils nearly the same value, and would have raised that value much higher than those obtained.

It will be seen that the greatest and most important task in meeting severe lubricating requirements is to mix with the clean base oil the required amount of animal fat. It might be added that this point must be located between very narrow limits, as an insufficient amount

Fig. 3. Horsepower-Hours per Gal. with and without Graphite

Fig. 4. Showing Decrease in Oil Consumption

Fig. 5. Time Engine Ran without Lubricants

fails to give the required lubrication, while an excess results in boiler troubles, insulation of condenser tubes, the formation of deposits in the steam spaces, and chemical action on the steam surfaces of valves and cylinders. The troubles and the difficulty experienced in attempting to meet the usual superheat conditions resulted in a series of experiments to determine the value of graphite or some more stable lubricant to assist the cylinder oil to meet the varying conditions without resorting to the use of animal fats, which, as stated, requires a delicate proportioning to meet the moisture conditions, and which are valueless in dealing with the superheat conditions. If it should meet these conditions, it would still have the objections described.

Tests were arranged to determine:

First. The mechanical action of graphite on the steam surfaces.

Second. If its use produced any injurious action on the cylinder walls.

Third. Its influence on the efficiency of cylinder oil and consequent effect on the cost of lubrication.

Fourth. If its use would produce deposits in the oil grooves and ring slots of piston valves, etc.

Fifth. If it could be substituted for the animal fat and thereby eliminate the uncertainty of compounding and the objectionable features of the tallow.

Sixth. If any injurious effect would be produced in the boilers if carried back by the condensate.

The first test was to take a sample from a highly-polished cylinder which had been operated with a high-quality cylinder oil, which under the microscope showed a rough surface with not more than 25 per cent of the area as effective surface. This condition was the result of the usual porosity of the iron together with the tool marks. The same cylinder was then lubricated with graphite and oil for two months and another sample examined with entirely different results. The interstices of the iron had been filled with graphite and the surface covered with a film of it. The action resulted in filling up the low section of the iron and thereby increasing the bearing surface. The depressions acting as reservoirs took the graphite from the steam and gave it up to the piston as it passed over it, producing a very substantial low friction surface to support the moving parts.

The iron was then subjected to an oxygen flame in which the graphite became incandescent, showing very plainly its presence and distribution throughout the metal. A thorough examination failed to reveal any objectionable conditions in the cylinder and this has remained true through two years of operation.

To determine the efficiency of amorphous graphite as a lubricant, a high-pressure cylinder of a compound engine having excessive lap and using high-pressure steam was used. By feeding the minimum amount of oil necessary to lubricate the cylinder, a value was determined by the number of hours the engine would run on a gallon of the oil. After repeated trials it was found that the values ran from 6 to 12 hr. per gal. with what might be considered standard high-grade oils. The same oils treated with graphite gave an almost uniform value of 22 hr., equivalent to an increase of 83 per cent. This figure was very closely approached in regular operation, as may be seen by observing the curve, Fig. 3. The lower part of the curve represents the average of three months' consumption of oil without graphite and fed with hydrostatic lubricator, while the upper part shows the effect of oil with graphite, using an improved lubricator. The increase is approximately 139 per cent. The same effect is illustrated in Fig. 4. The upper line represents a month's consumption of oil with hydrostatic lubricators. The middle line represents the same condition with a small amount of graphite, while the lower line was produced during the third month with sufficient graphite and an improved method of feeding, i.e., preventing settlement of the graphite in the oil.

To test the durability of graphite as a lubricant the engine was lubricated with cylinder oil for a few days,

then the supply of oil was suddenly stopped. After 20 min. it was necessary to reëstablish lubrication. The same experiment with the graphite mixture enabled the engine to run 57 min. before lubrication was again necessary. This is graphically shown in Fig. 5, where the difference in the two lines represents the difference in the durability of the two methods.

The question of deposits was taken up by collecting samples of accumulation from low-pressure cylinders, gas engines and every place where graphite has been used. In some cases the engineer had emphatically stated that the deposit was the result of the use of graphite, but in no case was graphite found to be present more than by 12 per cent., and mostly at an average of 7 or 8 per cent., the balance being animal matter, iron and sand with some carbonized oil.

Curve *A*, Fig. 6, represents the action of oil without animal fat. After the effects of previous graphite lubrication had disappeared, the value of the oil fell very

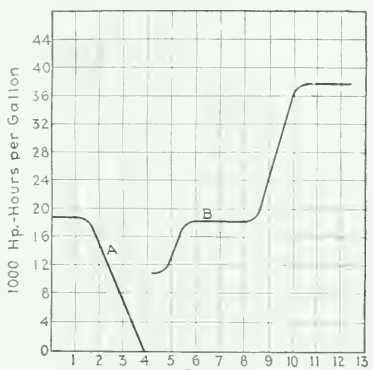


Fig. 6. Action of Oil Without Animal Fats and of Same Oil Treated with Graphite

rapidly. On the fourth day it became necessary to discontinue its use, even though large quantities of the oil were being fed. Upon examination the valves showed indication of cutting. The same oil was then treated with graphite, which not only corrected the previous conditions but gave very satisfactory lubrication at high efficiency, as is shown by the curve *B*.

To test the effect of graphite on boilers, 200 lb. of graphite was introduced with the feed water for a period of three months without producing anything but beneficial results.

The results of the experiments justify the opinion that the action of graphite on steam surfaces is mechanical and positive, producing much better lubrication than can be obtained by the use of cylinder oil alone. Also, that no injurious action results from its use either in engine cylinders or the boilers, and, further, that its use increases the efficiency of cylinder oil from 40 to 100 per cent. That deposits will not form any more rapidly than when cylinder oil containing animal fat is used. In most cases the graphite can be substituted for the animal fat, when a constant mixture of it and cylinder oil in predetermined proportions is fed to the cylinder.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The "Engineering Record" says that the engineer is best fitted for the work of mosquito extermination. At last we find a practical meaning for the "M. E." so often tacked on the end of the engineer's name: Mosquito Exterminator! Go to it, M. E.; swat 'em!

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No corporation, can remain soulless after Doctor Cupid gets his strangle-hold on it. The Georgia Ry. & Power Co. has fallen under the wiles of this heart specialist, who prescribes matrimony as an efficiency tonic for its employees. A single man may now have his Sunday afternoons off in an endeavor to decrease the visible supply of old maids. Getting married is hard work, but the way you have to hustle afterward makes you forget it to some extent.

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For doggone meanness, nothing equals those swindlers who, under the name of "college," rob young men of their savings by inducing them to take a course in their "colleges." "Leslie's Weekly" says there are several fake institutions carrying on such work. It's not difficult to get the endorsement of people who know the standing of a reputable school, and you don't have to take the school's say-so, either.

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Some 50 years ago a paper was published in New York called the "Quadruple Constellation." It was only 24 pages, but the size of them, as Cassidy said, would paper a house. The sheets measured 70 by 100 in., divided into 13 columns, each 48 in. long. The editor intended publishing it every hundred years. It took 40 people eight weeks to compile it. This sounds like a joke, but it's an historical fact; a man in Philadelphia has a copy. By the time he gets issue No. 2 he'll have to build a garage to keep the two of them on file.

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SOME REFLECTIONS ON THE WATER

Editor the Spillway:

Sir: Of course you have come in more or less contact with water. Have any confidence in it? Do you respect it? Well, I don't; leastwise Croton water. It's chock full of "thallogenous, chlorophyllous cryptograms." By patient research you will find that this unpronounceable mess is algae, or seaweed. I don't hanker for a drink that demands the use of the slicebar to break it up before it will flow freely.

Seaweed is a food, a recreation, may be. Mixed with H_2O, it's a good reason for a $10,000 suit against the editor who says you use it promiscuously. I take my seaweed plain, unfiltered and externally, down to the seaside.

Along about July, on my lay off, I hie me to the shore, modestly array myself in the bathing habiliments my fond wife thinks so becoming, and sportively plunge into the briny deep. It's then I get my seaweed and water. Sometimes I get more than this. If the tide is low I may come to the surface in the warm embrace of a pair of last season's corsets, or closely attended by a badly worn watermelon. (One summer I collected beer-bottles—with the soles of my feet.)

On rare occasions I have, for a brief interval kept company with a deceased feline or a more or less perfectly good dog that, despairing of my coming some six weeks before, gave up his young life and just patiently floated around loose in the meanwhile—admitting that a dog can become loose in the meanwhile. Draped in sufficient seaweed, with a blue or green background of salt water, these surroundings are merely picturesque if you don't take a day off too often.

And no one would for a moment intentionally accept any of these incidentals internally. They are honest, they make no pretense of being other than they are. But this Croton stuff basely steals unawares into our very midst; it travels under false pretenses. Masked by seaweed, Croton may contain pollywogs or molligoggles, embryonic lizards or jugglebloogers. Who knows? Who seems to care?

Even as a chaser, you can't be too particular about what you drink. Admitting that you abstemiously take a chaser, it's fearful to think that perhaps even this very minute you are a traveling aquarium or a human jar full of the aforementioned pernicious little cusses preserved in alcohol.

Seaweed, or algae, help yourself, is an excellent fertilizer, sir: it raises things, garden sass and vegetables. Croton, sir, raises my indignation.

Yours for better conditions.

ALGAE C. WEED.

MEMBERS OF THE NATIONAL DISTRICT HEATING ASSOCIATION ON THE ROOF OF THE CLAYPOOL HOTEL, INDIANAPOLIS, IND.

Heating Engineers Meet at Indianapolis

At Indianapolis and in the Claypool Hotel, on May 27 to 29, inclusive, the National District Heating Association held its fifth annual convention. The registered attendance was 150, and all were enthusiastic over the best meeting in the history of the association. The papers were good and varied in character, the exhibits were better than usual, and the efforts of the entertainment committee were highly appreciated.

Hon. C. A. Bookwalter welcomed the visitors and in the course of his address referred to central-station heating as the solution of the smoke problem. In the response Secretary Gaskill pointed out that Indianapolis had the largest central-heating system in the world.

In his address President De Wolf spoke of the work of the association and outlined a number of topics that it would be well to investigate. Losses in transmission lines need to be studied more carefully, economical methods of operation by the consumer should be devised and their importance brought to his attention, more uniformity in specifications was required, and it was the president's opinion that a cheaper method of carrying heavy peak loads was entirely practical. He emphasized the importance of central stations being prepared to give heating service, so that they might fully take the place of the private plant. Reference was made to the work of the various committees and in some instances their continuance recommended.

The secretary's report showed a net gain of four in the membership, making a total of 229. The destruction of the 1912 proceedings during the recent flood, entailing a loss of $400, was brought before the convention, and before the close of the meeting the full amount was subscribed. Routine business and the report of the committee on meters occupied the balance of the morning session. S. Morgan Bushnell, chairman, read the report which was more or less supplemental to the report of the 1912 committee. A number of meters of different type than those in last year's report were described, defects in present meter construction were pointed out, rules for the care and maintenance of some of the different types of meter were prepared, and an outline of meter department routine in a heating company was given. Another subject taken up by the committee was that of meter vs. flat rates for steam service. It was this part of the report which was subjected to a lengthy discussion.

E. Darrow, general manager of the Merchants Heat & Light Co., of Indianapolis, favored flat rates. Meter service tends to develop a peak at practically the same time as the electric service, so that the demand on the station is intensified. At his plant both the electric and heating peaks came from seven to eight in the morning and four to six in the afternoon. The flat-rate service uses the equipment throughout the 24 hr. fairly equally and tends to fill up the valleys. On the system, however, automatic regulation maintains the temperature at 70 deg., and with this control from the power house, the steam consumption need be no more and may be less than would be required by a metered service.

A number of interesting discussions followed and all favored meter service. In one case cited, a change from flat rate to meters had increased the revenue 50 per cent. and cut the coal bill in half. In another case the saving in steam consumption was estimated at 15 to 20 per cent. With no station control of temperature, meters will without doubt effect a considerable saving and especially after the customers have learned how to regulate their services. With the system automatically controlled, a reduction of pressure and temperature rather than cutting off the steam is the proper solution of the problem. A. C. Rogers, of the Toledo Railways & Light Co., had found this method more economical and in subsequent discussion was confirmed by Mr. Darrow.

The educational committee, E. F. Capron, of Chicago, secretary, presented a code pertaining to important points in the installation of heating and ventilating plants, suggesting that the association coöperate with the American Institute of Architects, American Society of Heating and Ventilating Engineers, and the American Society of Mechanical Engineers.

"District Hot-Water Heating for Residences" was the title of the first paper, which was read by A. C. Rogers. The author arranged the paper under five general heads including Circulation, Radiation, Placing of Radiation, Water Temperatures and Atmospheric Conditions. Under the first heading sizes of piping, covering, valves, air pockets and air vents were touched upon. For determining the proper amount of radiation there were numerous formulas which gave as many different results. The author took a five-room plan and using thirteen formulas given in the paper, tabulated the results. A variation from the average as high as 10 per cent. was obtained. The water temperature depends a great deal on the amount of radiation installed. A table giving the

schedules of four different companies showed considerable variation for the same outdoor temperatures. The fifth division of the paper was devoted to humidity and wind.

N. M. Argabrite read a paper on the "Possibilities of Hot-Water Heat." In his opinion the greatest possibilities lie in improving and bringing up to date present systems by removing some of the wasteful auxiliaries, getting rid of open heaters and installing heater condensers so that the power end will have the advantage of the vacuum, installing thermostatic control for the consumers, improving the pipe insulation and reducing the steam consumption of the pumps by driving them electrically, the rate being approximately that of the main unit. In his plant the author ran one unit on the heating system, getting whatever vacuum the temperature of the water would permit. The balance of the electric load was run full condensing. Regulation of the water temperature was effected by shifting the electrical load, that is, in moderate weather the load on the unit carrying the heating is reduced, so that with less steam the temperature of the water can be maintained at a lower point. The author did not favor increasing the circulation and preferred the method just outlined to that in which the electric load is maintained and the vacuum adjusted to obtain the proper temperature for the water. Rates were given brief mention and the author made a strong point on increasing the electric load even at a reduction in rate so that there would be plenty of steam for the heating.

At the end of the afternoon session the nominating committee reported. The following officers were unanimously elected: President, S. Morgan Bushnell; first vice-president, E. Darrow; second vice-president, H. R. Wetherell; third vice-president, D. S. Boyden; secretary-treasurer, D. L. Gaskill; executive committee, C. F. Oehlman, W. A. Wolls and R. D. DeWolf.

On Wednesday morning, A. B. Biggs read the report of the committee on station records, telling why records were necessary and giving the following summary of those most useful.

1. Monthly and yearly cost report on all branches of operation: Thousands of pounds of steam sold. Tons coal consumed, price per ton and total fuel cost. Labor cost. Total operation cost. Operating cost per thousand pounds of steam sold. Total maintenance cost. Maintenance per thousand pounds of steam sold.

2. Monthly report showing: Amount of steam used. Amount of radiation added and cut out. Number of feet of mains and service laid. Number of meters set and removed.

3. Meters: Complete record of all tests and repairs.

4. Cubical contents: Exposed wall and glass, amount of radiation installed and amount required for all buildings connected to mains.

5. Mains and services installed: Size, length, square feet of heating service and exact location of pipes and fittings.

In the discussion, Mr. Boyden pointed out that it was specially important to keep a record of the exhaust steam and also of the live steam used in the system. Then by subtracting the meter readings the unaccounted for steam would be determined and it would be an easy matter to accurately compare the operation of different plants.

N. M. Argabrite thought analysis of operation a most important factor. In the plants belonging to his company close records of coal and water and data on draft and load were kept, so that it was possible to know exactly at any hour of day what each department was doing. In addition a bulletin containing the records was sent out every two weeks so that the different plants could compare results.

"Recent Improvements in Boiler-Plant Design and Operation," by Norman C. Reinicker was the next topic. Of the many radical changes made in boiler-room practice during the last few years, the greatest has been the installation of large boiler units such as those now in commission at the Delray plant of the Detroit Edison Co. Seven "special" type W 2365-hp. Stirling boilers are now operating and two more are in process of erection. These large boilers are just as reliable as smaller units, more efficient and it is possible to operate one side with a reduction in capacity of only 40 per cent. In practice these boilers have been operated efficiently over a range of from 50 to 225 per cent. of rating.

Another change in boiler-plant practice in the last few years has been the perfection and general acceptance of the underfeed type of stoker for high-grade bituminous coals. More attention is being paid to coal analysis, boiler-room instruments are being improved, electric motors in the boiler room are replacing steam-driven auxiliaries, the centrifugal boiler-feed pump is replacing the old duplex type and feed-water regulators are being perfected to give continuous feed. Results of changes of baffles in Stirling boilers made at the Delray plant during the last year were discussed. With the improved baffling slightly greater efficiency was obtained and considerable decrease in repairs to brick walls. A short discussion on bleeder turbines followed.

S. M. Bushnell, the newly elected president, then addressed the convention briefly. He spoke of the better work that can be done by small organizations. For this very reason the larger associations divide up into sections. He had heard no talk of the present organization combining with some larger society, and it was his hope that they would continue in the same way carrying on the good work that they had done in the past. Discussion on changes in the constitution, reclassification of some of the members, raising the dues, and raising the funds to cover the loss by flood took up the balance of the morning session.

On Wednesday afternoon, H. W. Prentis, Jr., of the Armstrong Cork Co., gave a very interesting talk on the insulation of underground pipe lines, which was illustrated by a series of lantern slides.

G. E. Quinan spoke at length on the power plants and heating business of the Puget Sound Light & Power Co., of Seattle, Wash. The company has a total of 500,000 sq.ft. of radiation which is supplied with live steam reduced to a pressure of 5 to 10 lb. at the plant, as most of the electrical load is generated by water power. The report was full of interesting facts and was highly appreciated.

Secretary Gaskill, in his paper on "Commission Control of Public Utilities," spoke highly of the state commission, the requirements for proper control, and the better feeling between the utility and the public after a competent commission has had a few years' experience and has been given ample funds and power.

"Appraisal of Heating Properties," by Harold Almert, followed and both papers were discussed on Thursday morning. Mr. Almert spoke mostly on legislation calling for inquiry into, or the restriction of, profits earned by public-service corporations. He dwelt upon the ignorance of many legislators on the operation of public utilities and the limitations of the commissions appointed. He urged every company to carefully analyze its own situation and if time or talent were not at hand, engineering firms of recognized standing could be retained to make a careful and comprehensive appraisal. Real indisputable facts as a fortification against the council or commission are wanted and it pays to select competent experts to get them. During the discussion, Mr. Almert thoroughly explained "going value," and some time was given to the attitude of the commissions toward electric and heating companies.

"Is District Heating Profitable to the Central Station?" This was the question allotted to C. J. Davidson, and in his paper he analyzed in part the divergency of opinion between the public and the central-station men. The public think that the gross receipts are on the credit side of the ledger, as the exhaust steam used is a byproduct which otherwise would be wasted. General opinion among central-station men is to the effect that there is no money in the heating business. A number of cases were cited to support the latter view. The conditions under which a power plant can advantageously supply heating service were discussed from the power-plant end, the street mains, and from the standpoint of rates.

A short discussion followed on the corrosion of cast iron, wrought iron and steel pipes. D. K. Mason, of the National Tube Co., cited an investigation by Dr. W. H. Walker, of the Massachusetts Institute of Technology to show that there is very little difference in the corrosion of iron or steel pipes.

In his paper on "Operating Economies in Heating Large Factory Buildings," Edward L. Wilder, of the Rochester Railway & Light Co., gave results from educating two large customers. One case was a four-story factory building built of brick. It had a total floor area of 60,000 sq.ft. and was heated entirely by direct radiation. By seeing that all windows were shut at the close of the working day, that the steam was entirely shut off and turned on again in the morning in time to have the factory comfortably warm by seven o'clock, the saving averaged 37 per cent. In another case a group of brick factory buildings, covering 75,000 sq.ft. of ground area and varying in height from 5 to 7 stories, were heated mainly by the fan system. An investigation followed by a specific set of operating instructions resulted in an average decrease in steam consumption of 32 per cent.

The discussion following the paper turned to intermittent vs. continuous heating. Mr. Boyden thought continuous heating more economical when the temperature was below 30 deg. F., and it resulted in better service. Others discussing the subject favored continuous heating at all times when the interval was not greater than 24 to 48 hr. Mr. Wilder strongly advocated intermittent heating. In many buildings, with steam left on, the temperature often ran up as high as 80 deg. during the night hours, so that the building loss was excessive. It was the opinion of President De Wolf that the method of operation would vary with different installations and that a choice must be made in each individual case.

Just before the convention adjourned, it was decided to appoint committees on underground construction and publicity. The afternoon was spent in visiting the plant of the Merchants Heat & Light Co., and other points of interest in the heating line.

In the entertainment Western hospitality was apparent. There were automobile trips to the Country Club and theater parties for the ladies, on Tuesday night a "get-to-gether" dance, buffet lunch and cabaret for all and on Wednesday evening a theater party.

Exhibits of underground conduit and heating specialties were made by the American District Steam Co., the V. D. Anderson Co., Armstrong Cork Co., Central Station Steam Co., Detroit Lubricator Co., General Electric Co., the Hardy Paint & Varnish Co., Jenkins Bros., H. W. Johns-Manville Co., the Michigan Pipe Co., the Ric-wil Underground Pipe Covering Co., the W. H. Schott Co., the Hohmann & Maurer division of the Taylor Instrument Co., and A. Wyckoff & Son Co.

Iowa N. A. S. E. Convention

The ninth annual convention of the Iowa State Association of the National Association of Stationary Engineers was held in Burlington, on May 21, 22 and 23, with the Hotel Burlington as headquarters.

The mechanical exposition of the Central States Exhibitors' Association, held in the banquet hall of the hotel, was formally opened on Wednesday at 10:30 a.m. At 1:30 p.m., State President A. E. Powell called the convention to order and Mayor F. C. Norton delivered the address of welcome. After National Secretary Fred Raven's response a visit was made to the shops of the Murray Iron Works Co., builder of Corliss engines and steam boilers.

At the evening exercises E. E. Egan, secretary of the Burlington Commercial Exchange, welcomed the delegates and visitors on behalf of that body and National President McGrath gave a brief address on "The Aims and Objects of the N. A. S. E." An informal smoker given by the exhibitors' association followed.

After the business session of Thursday morning, Adolph Shane, dean of the department of engineering at Highland Park College, Des Moines, lectured on "The Testing of Power Plants." After the afternoon business session C. A. Orr, chief engineer of the Morrell Packing Co., Ottumwa, lectured on "The Burning of Iowa Coal." Following this the delegates and friends went to the Burlington Base Ball Park as guests of the Riley Pennsylvania Oil Co., Burlington, and witnessed a game between the Burlington and Cedar Rapids teams of the Central Association. In the evening, a public reception was held by the exhibitors in the exposition hall.

Friday was taken up by an excursion down the Mississippi River to Keokuk on the "St. Paul," the delegates, visiting engineers, supply men and their families being the guests of the Murray Iron Works Co. The boat left Burlington at 8 a.m., and returned at 8:30 p.m. At Keokuk the mammoth dam and hydro-electric plant of the Mississippi River Power Co. was inspected. The final business session was held on the return trip, at which the following were elected to office for the present year: John Devine, Des Moines, president; Abner Davis, Cedar Rapids, reëlected secretary.

Throughout the convention ample entertainment was provided for the lady guests by a competent committee, including launch rides on the river, auto and trolley rides in and about the city and visits to Crapo Park, a natural beauty spot overlooking the Mississippi.

The next convention will be held at Des Moines.

Missouri N. A. S. E. Convention

The high standard established by the two conventions of the Missouri State Association of Stationary Engineers was fully sustained by the third annual convention which met at Springfield on May 14, for a three-day term. The number of delegates and guests was large and enthusiasm ran high.

At the preliminary exercises on Wednesday afternoon, the Rev. G. L. Peters made the invocation, after which O. M. Evans, chairman of the local committee, introduced Mayor George W. Culler, of Springfield, who welcomed the convention to the city. National Secretary Fred W. Raven responded on behalf of the association in the absence of President McGrath. State President F. H. Munsberg then delivered a brief address.

At this session, W. A. Vincent, chief inspector for the Missouri Fidelity & Casualty Co., gave a paper on "Steam Boiler Explosions," and Fred Key, another chief inspector for the same company, presented one on "Indicator Practice."

In the evening, Charles Cullen, secretary of the Central States Exhibitors Association formally opened the exhibit in a hall at the Metropolitan Hotel by welcoming the delegates and visitors on behalf of his associates. Following an inspection of the exhibits an informal reception and entertainment were given by the exhibitors' association.

The convention proper was opened on Thursday morning by State President Munsberg, after an address by National Secretary Raven. In the afternoon another business session was held and at its conclusion a visit was paid to the new railway shops of the Frisco System, the ladies enjoying, in the meantime, an automobile ride about town as the guests of the Springfield Automobile Club.

In the evening Edward H. Lane, chief engineer of the Commerce Building, Kansas City, gave an instructive lecture on "Steam Boilers," and H. W. Hibbard, professor of mechanical engineering at the University of Missouri, Columbia, Mo., lectured on "Scientific Management in the Power Plant."

On Friday morning public exercises were held at which addresses were made by Secretary Charles Cullen, of the exhibitors association; Charles Parkinson, Missouri State deputy, and J. J. White, past state president. The annual election resulted in the selection of the following officers for the ensuing year: D. M. Trimble, Kansas City, president; J. H. Chesnutt, Springfield, vice-president; A. P. Maeder, Joplin, reëlected, treasurer; E. H. Lane, Kansas City, secretary.

In the afternoon a trolley ride was taken to Doling Park where a base-ball game was played by teams representing the engineers and the exhibitors, the former winning easily. In the evening a grand ball and public installation of officers was held at the Springfield Club.

Next year the convention will take place at St. Joseph.

Periodical Boiler Inspection in England

The following is taken from the annual report of the Manchester (England) Steam Users' Association:

It may be of interest to mention that the system of periodical boiler inspection inaugurated by the association in 1854 has been generally adopted in this country, and that now, aided by the Factory and Workshop Act, there are very few boilers remaining uninspected. In other countries, too, the system has been followed, so that the association may fairly be described as the parent of universal boiler inspection. In America, however, where inspection does not appear to have taken such deep root, the number of boiler accidents is still very great, in illustration of which it may be mentioned that, according to recently published statistics, there occurred in that country during the month of October last as many as 54 explosions, killing 20 persons and injuring 39 others.

Outside its ranks the association has noted throughout the United Kingdom during the year the occurrence of 68 explosions, killing 34 persons and injuring 49 others. Of these, 17, killing 9 persons and injuring 13 others, may be termed "boiler explosions proper," while the remaining 51, killing 25 persons and injuring 36 others, may be termed "Miscellaneous" explosions, i.e., those arising from steam pipes, stop valves, kiers, drying cylinders, bakers' ovens, economizers, etc. In addition to the above, one explosion arose from the bursting of a kitchen boiler, no personal injury resulting.

Air-Tank Explosion

On May 24, a huge tank of compressed air exploded at the plant of the Parrish & Bingham Co.'s foundry, Cleveland, Ohio. The engineer was thrown 15 ft. and severely injured. The building interior was partly wrecked and the windows broken.

Most of the foundry machinery is operated by compressed air. According to the daily press reports, the engineer had started the pumps to refill the tank and the pressure got too high before he noticed it.

Annual Exhibit of Day Work at Pratt Institute

The annual exhibit of the work of day students of Pratt Institute will be held as follows: Thursday, June 12, 2 p.m. to 5 p.m.; Friday, June 13, 10 a.m. to 5 p.m.; Saturday, June 14, 10 a.m. to 5 p.m.

This exhibit is open to the public and affords those interested in industrial and technical education an opportunity

not only of viewing the work of the students in the various courses, but also of inspecting the methods as well as the equipment of the school and its general facilities for conducting this kind of training.

The institute offers day and evening courses for both men and women in a wide variety of vocational subjects, including fine and applied arts, architectural design and construction and technical and trade courses for men along several important lines.

The work of the School of Science and Technology should prove of especial interest to men engaged in technical and trade pursuits. This school provides instruction in applied mechanics, applied electricity, applied chemistry and tanning, machine work and tool making; plumbing, carpentry and building and pattern making.

New University of Illinois Buildings

The recently completed transportation building, locomotive laboratory and mining laboratory at the University of Illinois, Urbana-Champaign, Ill., were dedicated on May 9. Simultaneously, a railway and a mining conference were conducted at the university.

The preliminary dedication ceremonies were held in the auditorium on Thursday evening, May 8, Dr. E. J. James, president of the university, presiding. Samuel Insull, president of the Commonwealth Edison Co., Chicago, spoke of the rapid progress made in the development of the science and business of generating and distributing electricity for light and power.

J. G. Pangborn, special representative of the Baltimore & Ohio Railroad, traced the history of railroad development from its very beginning and dwelt particularly upon the vicissitudes of the inventors of the early locomotives.

Capt. Robert W. Hunt, president of R. W. Hunt & Co., Chicago, spoke of the importance of conserving the coal resources.

The railway and the mining conferences convened on Friday morning at 9 a.m., and subsequently sessions were held Friday evening and Saturday morning. Many important and interesting subjects were discussed.

The dedicatory ceremonies were conducted in the Auditorium on Friday afternoon, Dean W. F. M. Goss, of the college of engineering, presiding. After Rev. Charles Ryan Adams, of the First Presbyterian Church of Champaign, pronounced the invocation, Dr. Edmund J. James, president of the university, delivered the address of dedication. The Hon. W. L. Abbott, president of the board of trustees, responded on behalf of Governor Dunne, who was unavoidably detained at Springfield.

Prior to these ceremonies, a luncheon was served to the guests in the armory at 12:30, after which two hours were spent in inspecting the various university buildings and equipment. After the exercises, the assemblage, headed by the university band, marched to the main entrance of the transportation building where the Rev. Mr. Adams made a brief prayer of dedication.

The transportation building, the principal structure of the group, is a three-story building 143 ft. long and 65 ft. wide. It is designed primarily to be occupied by the department of railway engineering, but the upper floors are temporarily assigned to the department of mining engineering and the department of general engineering drawing. Accessory to this building is the locomotive laboratory, the mining laboratory and ceramics laboratory. The plan for the group of buildings of which these constitute a part provides for a railway electrical laboratory and a railway museum.

The locomotive laboratory is a brick and steel structure 117 ft. long and 43 ft. wide, and is served by a track connection with the Illinois Traction System. The laboratory is to provide means for testing locomotives under conditions similar to those prevailing in service. The mounting mechanism for receiving the locomotives to be tested is of original design and will accommodate the largest locomotive, not excepting those of the Mallet type. A locomotive mounted upon the testing plant may be fired and operated in the same way as upon the road.

Hydraulic friction brakes of enormous capacities mounted upon the axles of the supporting wheels serve to supply a load for the locomotive. The drawbar of a locomotive on the plant is coupled to a traction dynamometer, a device for measuring the pull exerted by the locomotive. The capacity of the dynamometer is such as to permit the measurement of a force as great as 125,000 lb. and yet it is so delicate as to permit great accuracy when the forces to be measured are small.

The main mining laboratory occupies a building 42 ft. wide and 100 ft. long, situated just east of the transportation building. It has four parts: 1. A chemical laboratory equipped with appliances for the analysis, assay and testing of coal and ore; 2. A drill and explosive laboratory containing regular machines and sectional models of the principal types of rock drills and coal cutters and appliances for testing blasting powders and for instructing students in the use of explosives; 3. A mine rescue station where the principal types of rescue apparatus are on exhibition and students are given instruction in first-aid and mine rescue work. 4. A coal-washing and ore-dressing laboratory. These laboratories are well equipped both for the instruction of students and for the testing of coals, ores and machinery. Tests of Illinois coals have already been run and a stock of gold ore from the Black Hills, lead and zinc ores, and fluorspar from southern Illinois are ready for future treatment.

PERSONALS

E. T. Scholer has been appointed manager of the electric-light station at Nezperce, recently acquired by the Grangeville (Idaho) Electric Light & Power Co., Ltd.

H. A. Mentz will be the engineer in charge of the Solomon-Norcross Co.'s branch office in Memphis, Tenn. Mr. Mentz is a member of the American Institute of Electrical Engineers.

J. P. Moore, formerly with the Westinghouse Electric & Manufacturing Co., has been made superintendent of power and equipment of the People's Incandescent Light Co., Meadville, Penn.

F. J. Derge has been appointed manager of light, heat and power for the Toledo (Ohio) Rys. & Light Co. Mr. Derge was, until his removal to Toledo, a member of the New York staff of H. L. Doherty & Co.

E. H. Clark has resigned as superintendent of power and shops of the Indianapolis, New Castle & Eastern Traction Co., New Castle, Ind., to accept a similar position with the Southern Illinois Ry. & Power Co., Harrisburg, Ill.

OBITUARY

HORACE G. BURT

Horace Greeley Burt, ex-president of the Union Pacific R.R. System and later chief engineer of the Chicago Association of Commerce Smoke Abatement Committee, died May 19. He was 54 years old.

STEPHEN D. FIELD

Stephen Dudley Field, F. Am. Inst. E. E., inventor of electrical devices, died at his home in Stockbridge, Mass., May 18, aged 68 years. He was born in Stockbridge and was a nephew of Cyrus W. Field, famous for having laid the first transatlantic submarine cable.

Stephen Dudley Field invented a multiple-call telegraph box in 1874 and an electric elevator in 1878; he was pioneer experimenter and inventor of electric railway equipment, and in 1879 he made the first application of dynamo machines to telegraphy. The following year he invented a dynamo quadruplex telegraph, in 1884 a fast stock ticker, and in 1909 made the first application of quadruplex telegraphy to submarine cables on the line between Key West, Fla., and Havana, Cuba. Mr. Field was also a member of the Institution of Electrical Engineers of Great Britain.

BUSINESS ITEMS

The Joseph Dixon Crucible Co., Jersey City, N. J., has issued a new brush booklet, which fully describes Dixon's graphite brushes for dynamos and motors. It is mailed on request.

An attractive folder has recently been published by the Griscom-Russell Co., 90 West St., New York, describing the Russell steam engines, Goubert feed-water heaters, Reilly multicoil heaters, Stratton steam-receiver separators and many other Griscom-Russell products. A copy will be mailed to anyone on receipt of request.

E. J. Rooksby & Co., 435 North 11th St., Philadelphia, have issued a booklet descriptive of a number of classes of engine repairs made by them and of their engine specialties designed to secure the highest efficiency and economy in the production of power. Copies will be mailed free to any interested parties.

POWER

Vol. 37 NEW YORK, JUNE 17, 1913 No. 24

Getting Out of the Rut

IN most power plants the recurrence of routine work tends to get the engineer in a rut. Unless he guards against it, he is likely to become too easy-going.

Yes, reader, we are prepared to hear that *your* conditions are not such. In addition to your regular duties, you never know when you may be called upon to repair a trap or show the engines to visitors. But, with all these distractions, isn't it true that a good many hours each month vanish without much to show for them, other than a well kept station log and a clean slate so far as breakdowns or stops of apparatus are concerned?

How can one overcome the habit of letting time slip away without doing any more than the least necessary to keep the plant in good condition? The secret is contained in five words, DON'T LOAF ON THE JOB! True, most of us have to make a big effort to work harder than we absolutely have to; but the fellow ambitious to attain unto large responsibilities and their commensurate rewards, never gets there and *stays* unless willing to sacrifice temporary comfort to future welfare.

Some engineers find the days too short for all that needs to be done. But, on the other hand, there are countless installations where the productive "load factor" of the engineer as an efficient personality is far below what it might be in relation to his mental and ultimate financial advancement.

To "get down to brass tacks," here are some of the practical ways in which a man can lift himself out of the rut and get a firmer grip on the rear platform rail of the Prosperity Limited as she slows down a bit in passing his station.

First: Make a closer study of the plant itself. Take a few photographs of the interesting features, if you are a camera enthusiast, and frame one or two and show them to the "boss." Keep a few extra unmounted prints in the drawer for visiting friends and the representatives of the engineering periodicals, who may happen in in search of a story. If a scale plan of the installation is not on hand or up to date, make one on tracing cloth so that blue prints may be made when needed. Then try your hand at an elevation or section. Get some loose-leaf sheets and make simple diagrams of all piping and valve relations, and do not forget to make a quick reference list of every piece of machinery in the plant, giving its size and capacity, make, floor space, and other particulars likely to be desired "off the bat" by the general manager. Get permission, if possible, to go through the office files and read every letter bearing upon your department, and if your enthusiasm is still good, start a file of your own which shall be run with the object of becoming the best source of complete information on the plant around the premises. Last, but not least, overhaul your desk and see that it stays in order and that the technical journals which come in are at least removed from their wrappers and put in chronological order in an accessible place.

Second: Appoint yourself a committee of one to study plant efficiency. If you cannot get authority to make improvements needed do not forget them, but get them down in black and white for future reference. See that your logs compare favorably with those of similar plants elsewhere and "get the load-curve habit." To improve the operating economy is your most important duty next to giving continuous service. Remember, you may be called upon some day to show the owner why he should continue to run an isolated plant instead of buying outside service. If he should, you must be prepared for keen, close questioning which must come in such cases.

Third: Read at least one technical journal regularly and attend local engineering society and club meetings which bear upon your special practice. If the manager sees an engineering paper on your desk he is not likely to think that you are wasting your idle moments. Visit other plants in your territory; learn to write grammatical, straightforward letters and reports; ask the public library to buy the technical books you think you ought to have and in general open up the doors and windows of your personality to let in the light of outside practice and the invigorating fresh air of other men's views and interest.

In a nutshell, realize that you live in an age of opportunity, and reach after fullness of life in every direction associated with your calling.

[*H. S. Knowlton, Newton, Mass.*]

Lazwell Drainage-Pumping Plant

SYNOPSIS—This pumping plant is used to drain an area of approximately fifty thousand acres of swamp land. Three Lentz condensing engines are directly connected to three 54-in. centrifugal pumps. Three water-tube boilers with induced draft supply steam at 150 lb. pressure, superheated 125 deg.

While vast areas of swamp and overflowed land in the United States have been reclaimed there remain upward of 75,000,000 acres to be drained and about 150,000,000 acres that require more thorough draining to make them more productive. Over half of the as-yet-undrained land lies in the Mississippi Valley, where pumping is necessary in many places because the land lies below the river level.

FIG. 1. GENERAL VIEW OF THE PUMPING PLANT AND SUCTION BAY

The principal parts of the problem of drainage by pumping are: First, the design of the pumping plant to produce reliability of operation, economy in operation and low maintenance; second, the maintenance and operation of the plant in a manner to insure reliability and the best possible plant efficiency under the various conditions of pumping head.

The Lazwell plant of the Des Moines County Drainage District No. 1 is a good illustration of a modern plant, laid out and operated to satisfy these factors.

The plant is located about nine miles north of Burlington, Iowa, on the west bank of the Mississippi River and drains a district embracing 50,000 acres, extending from Burlington to Oakville. The general view, Fig. 1, shows a part of the suction bay and one of the discharge pipes extending over the crest of the levee. As induced draft is used, the chimney extends but 10 ft. above the roof. The one-story building is 32 ft. high, and 70x80 ft. in area. The walls are of common brick and the roof is of tar and gravel over flat arch tiles supported on steelwork. A 12-in. transverse partition wall divides the building into an engine room, 37 ft., and a boiler room, 40 ft. wide.

There are three 54-in., double-suction, centrifugal pumps, directly connected to three 350-hp. Lentz 14½ and 24 by 27-in. tandem-compound steam engines, with normal speeds of 130 r.p.m. The units are placed diagonally, to economize space in the building itself and to bring the two 38-in. suction pipes of each pump close together in the suction bay. The engines are shown in Fig. 3.

One pipe is 16 ft. and the other 17 ft. long, and the intake end of one is one foot higher than the other. The pipes project straight down into the suction bay, which extends under the plant, and divides into three concrete chambers, one for each pump. The entrance to each chamber is protected by sets of removable iron racks to prevent coarse matter from getting into the pumps. The suction pipes are bell shape at the lower end, flaring to a diameter of 6 ft. to reduce entrance velocity and friction loss.

There are three discharge pipes with gradually increasing sectional area which are 128½ ft., 109 ft. 2 in. and 89 ft. 10 in. long, the difference in length being due to the position of the pumps. These pipes extend horizontally from the pumps to the crest of the levee and then to the concrete discharge bay in the river at an angle to the vertical of about 67 deg. The outlets are always under water and the pipes remain full or nearly so and the maximum benefit of the siphoning effect is obtained whether the pumps are running full capacity or not.

From the crest of the levee to the discharge end the pipes are not only buried in the earth, but are encased in concrete so that, although they may ultimately corrode away, it will never be necessary to renew them. The diameter of the pipes gradually increases from 54 in. at

FIG. 2. BOILER EQUIPMENT AT THE LAZWELL PLANT

the pumps to 90 in. at the outlets, thus reducing the friction loss to the lowest value. The static head varies from zero to 14 ft., depending on the stage of the river, the average depth of which is 6 ft.

The Lentz type of engine was purchased because of its simplicity of construction and the high operating efficiency guarantee made by the manufacturer. (A description of the engine was published in POWER, Dec. 31, 1912.) These engines are equipped with speed-changing mechanism, adjusted by turning a handwheel at the end of the valve-cam shaft, while the engine is in operation, if desired. This feature is important because, with the centrifugal pumps, slight variations in the static head require speed adjustment for good economy. Steam at 150 lb. gage pressure and 125 deg. F. superheat is used. Super-

heaters are located in the first pass of the boilers. The piping is of extra-heavy weight with screwed flanges.

There are three vertical water-tube boilers, each of 210 hp. rated capacity. Dutch-oven furnaces and shaking grates, suitable for burning 1¼-in. Illinois bituminous screenings purchased on the B.t.u. basis are used. The screenings are delivered to the plant in wagons and stored on a concrete platform alongside the boiler room, and wheeled in for use after weighing in barrowfuls. Two of the boilers are shown in Fig. 2.

Induced draft is produced by a squirrel-cage fan, 54 in. in diameter and 30 in. wide, driven by a 5x7-in. vertical engine. Induced draft was selected because of the cost of building a foundation for a chimney to furnish natural draft, the subsoil being of such a nature as to require piling. A small vertical tubular boiler is employed for starting up, as with the induced-draft system it would be a difficult matter to raise steam readily in one of the larger boilers when cold, as well as arduous work to fill the boilers by hand.

There are two 7½x5x6-in., duplex, outside-end packed, plunger-type feed pumps. Feed water is drawn from the drainage ditch and fed without treatment to an open heater. A venturi meter in the discharge line of the feed pumps records the quantity of feed water supplied.

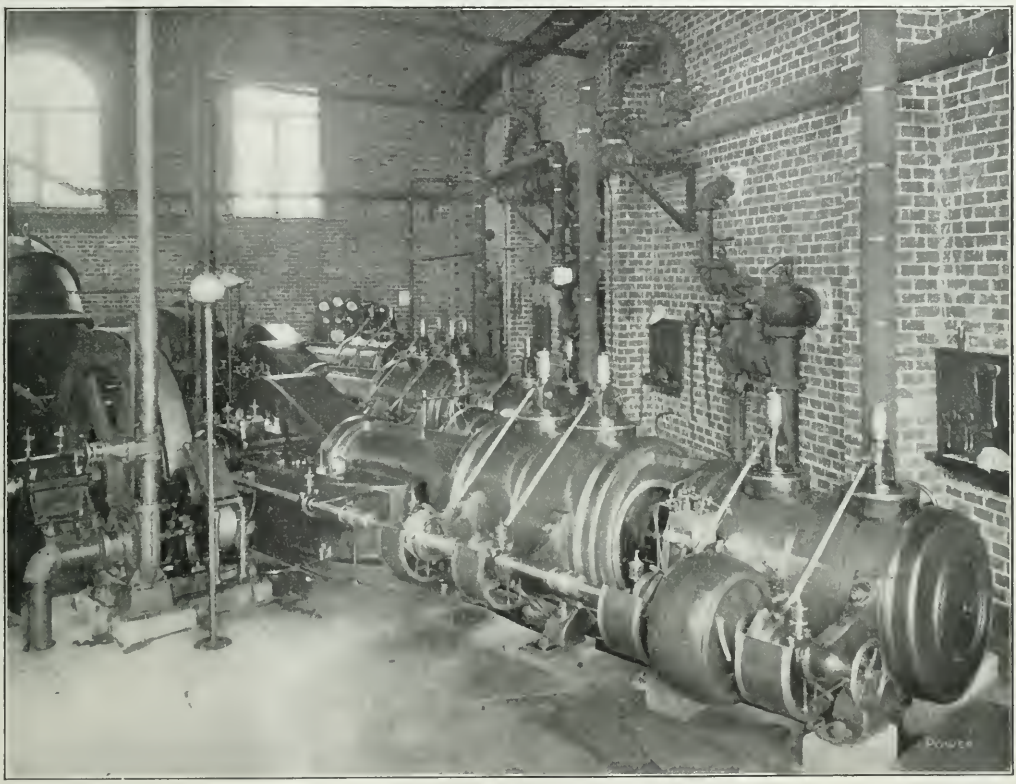


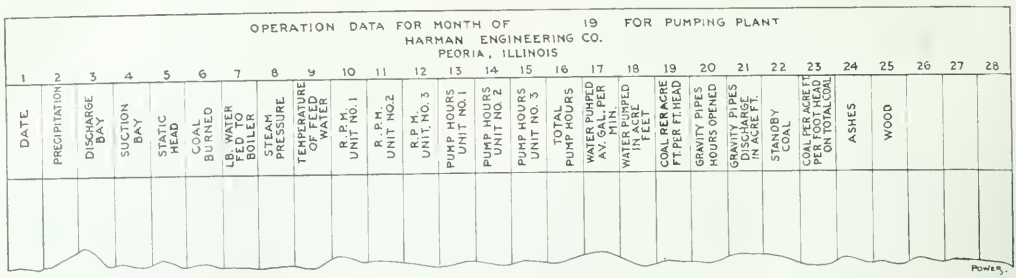
Fig. 3. Lentz Engines Driving Centrifugal Drainage Pumps

Each engine exhausts to an 8-in. "Eductor" condenser mounted on the wall between the engine and the boiler room. Injection water, also drawn from the drainage ditch, is supplied by individual 4-in. centrifugal pumps, driven through friction pulleys from the flywheel of the engines.

A small high-speed, engine-driven, direct-current dynamo supplies current for the lights about the plant. The maximum overall coal consumption, when operating at full rated capacity against a 7-ft. static head, was guaranteed not to exceed 128 lb. of dry coal per million gal-

PRINCIPAL EQUIPMENT OF THE LAZWELL DRAINAGE-PUMPING PLANT

No.	Equipment	Type	Service	Size	Hp.	Speed	Steam lb.	Manufacturers
3	Engines	Lentz	Drainage pumps	14½x24x27″	350	130	150	Erie City Iron Works
3	Pumps	Centrifugal	Drainage	54″		130		Henry R. Worthington
3	Boilers	Water tube	Steam		210		150	Erie City Iron Works
1	Fan	Squirrel cage	Draft	54″				Massachusetts Fan Co.
1	Engine	Vertical	Draft fan	5x7″				Troy Engine and Machine Co.
2	Pumps	Duplex	Boiler feed	7½x5x6″				Henry R. Worthington
1	Heater	Open	Feed water					Erie City Iron Works
1	Meter	Venturi	Feed water					Builders Iron Foundry
3	Condensers	Eductor	Engines	8″				Schutte-Koerting Co.
3	Superheaters	Foster	Boilers					Power Specialty Co.


OPERATION DATA FOR MONTH OF 19 FOR PUMPING PLANT
HARMAN ENGINEERING CO.
PEORIA, ILLINOIS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
DATE	PRECIPITATION	DISCHARGE BAY	SUCTION BAY	STATIC HEAD	COAL BURNED	LBS. WATER FED TO BOILER	STEAM PRESSURE	TEMPERATURE OF FEED WATER	R.P.M. UNIT NO. 1	R.P.M. UNIT NO. 2	R.P.M. UNIT NO. 3	PUMP HOURS UNIT NO. 1	PUMP HOURS UNIT NO. 2	PUMP HOURS UNIT NO. 3	TOTAL PUMP HOURS	WATER PUMPED AV. GAL. PER MIN.	WATER PUMPED IN ACRE FEET	COAL PER ACRE FT. PER FT. HEAD	GRAVITY PIPES HOURS OPENED	GRAVITY PIPES DISCHARGE FT. IN ACRE FT.	STANDBY COAL	COAL PER ACRE FT. PER FOOT HEAD ON TOTAL COAL	ASHES	WOOD			

POWER.

Fig. 4. Monthly Report Sheet

lons of water pumped. The guarantee is based on the operation of all three pumps and two of the boilers so as to give the auxiliaries their normal load. The coal is also specified as Fulton or Peoria County, Illinois, fifth-vein bituminous screened lump, the proximate analysis of which is about as follows:

	Per cent.
Moisture	10
Volatile	36
Fixed carbon	42
Ash	12
Heat value	11,200 B.t.u.

Method of Operation

The plant was designed and its operation is supervised by the Harman Engineering Co., Peoria, Ill. The coal contracts are made by this company and it systematically analyzes the coal delivered. The operating engineer at the plant submits a daily report, stating weather and working conditions; number and time of boilers in service; number and time of pumping units in operation and the revolution counter readings; water level in river and suction bay and the amount the level in the latter was lowered by the day's pumping; feed-water meter readings; weight of coal burned; labor employed, with description of work, hours and rate of pay; also, whatever other information that is pertinent, such as time of cleaning boilers, hot bearing developed, repairs made, etc. The engineer also sends in the charts from the recording steam gage and the recording thermometer for the feed-water temperature. From these reports the form shown in Fig. 4 is filled out, which gives the complete record of a month's operation.

The purpose of this system of supervision is to maintain the plant at its highest efficiency and so save all unnecessary expense.

Temperature Tests on Journal Bearings

By Alan M. Bennett

SYNOPSIS—Comparative tests showing the temperature rise with ball-seated bearings of different metals under both forced lubrication and ring feed. The results of a test on a concentric-sleeve bearing are also included.

The curves here given are from the results of tests made by the writer for the purpose of determining the relative value of bearings of various designs and compositions, for high-speed duty, such as that met with in steam turbines, and their connected apparatus. It was decided that the tests should show, with temperature rise as a basis, the following specific comparisons:

First, that between bearings supplied with oil by ordinary ring feed and those in which forced lubrication was used; second, a comparison of results from the use of different materials under like conditions of lubrication, and, third, a comparison of the straight-seated and self-aligning types. In addition, from the last two series, was to be observed the effect on vibration of the various materials and methods of mounting.

The tests were made on journal-type bearings fitted to an ordinary direct-current motor, and all were run under the same conditions of load, bearing pressure and speed. In each case the run was continued until a constant temperature had been reached. The motor was run free, as it was thought that the resultant pressure on the bearings, due to the weight of the armature, load and varying tightness of belt would be difficult to accurately determine for each case. Besides, the condition of running free, so far as the bearings were concerned, more nearly approached that found in turbine sets, where the driving and driven machines are usually in line with each other, either coupled or on the same shaft.

The self-aligning bearings were all of the ordinary ball-seated type with one exception, that being composed of three concentric sleeves with oil clearances between them, the outer sleeve being doweled in the bracket, while the inner sleeves were free to rotate and accommodate themselves to irregularities of construction and alignment.

With the latter bearing, forced lubrication only was used, because of the difficulty of adapting it to ring feed. The oil was brought in at the top of the bearing through a 3/8-in. pipe under a pressure of approximately 2½ lb. per square inch. From the oil clearance between the outer sleeve and the one next to it, the oil was led by grooves and openings through the inner sleeves to the inner oil clearances and shaft. This method of bringing in the oil also obtained with the rest of the bearings in which forced feed was used. The ring feed was effected by means of two rings.

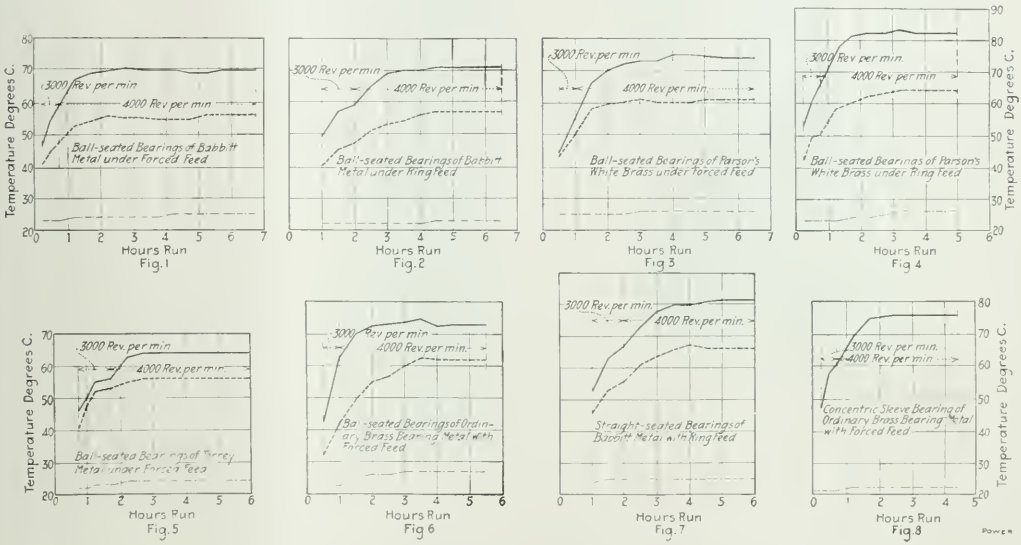
All the various bearings were of like size, having a nominal bore of 1¾ in., and a length of 5¼ in. The actual bore of the bearings was between 0.0025 and 0.003

in. larger than the journal diameter. The pressure per square inch of projected area on the front and back bearings was 23 and 28 lb. respectively.

A close estimate of the heating effect on a bearing can be obtained from the rubbing coefficient, or the product of the peripheral speed of the journal in feet per minute and the pressure per square inch of projected area. With a value for this coefficient of approximately 40,000, the bearings will show a temperature rise of 35 to 40 deg. C. the conditions of oil supply being favorable. At the foregoing pressures, and a speed of 4000 r.p.m. at which these tests were run, the values of the rubbing coefficient for the front and the back bearings

The curve in Fig. 8, for the concentric-sleeve bearing, is plotted from an average of two runs on the same bearing. So far as temperature rise is concerned, this does not offer any advantage over the bearings of ordinary construction, the temperature rise being practically as high as that of some of the other bearings with ring feed. With this bearing, however, the vibration of the machine was very perceptibly lessened, and it is probable that the increase in temperature can be accounted for by this fact, the vibration being absorbed in the bearing and manifested in heat.

With the straight-seated bearings, Fig. 7, the vibration was much more noticeable than with any of the self-


Temperature Degrees C.
Hours Run
3000 Rev. per min.
4000 Rev. per min.
Ball-seated Bearings of Babbitt Metal under Forced Feed
Fig. 1
Ball-seated Bearings of Babbitt Metal under Ring Feed
Fig. 2
Ball-seated Bearings of Parson's White Brass under Forced Feed
Fig. 3
Ball-seated Bearings of Parson's White Brass under Ring Feed
Fig. 4
Ball-seated Bearings of Parsons Metal under Forced Feed
Fig. 5
Ball-seated Bearings of Ordinary Brass Bearing Metal with Forced Feed
Fig. 6
Straight-seated Bearings of Babbitt Metal with Ring Feed
Fig. 7
Concentric Sleeve Bearing of Ordinary Brass Bearing Metal with Forced Feed
Fig. 8
POWER

Temperature Rise Plotted against Time of Running

respectively were 42,000 and 51,000. From this it will be seen that, even though the motor was running light, the bearings were well loaded.

Comparison of Results

The tests in Figs. 1 to 4 inclusive show that a forced oil supply at the pressure given has an advantage over ring feed in keeping down the temperature, the bearings under the former running cooler by an average of nearly 10 per cent. than those with the latter. This gain in temperature decrease, however, is offset by the added complication and expenses of providing means for pumping the oil through the bearings. To this must be added the possibility of breakdown and failure of the pump, a contingency not to be reckoned with when ring feed is used. Inspection of Figs. 1, 3, 5 and 6, which were run under forced feed, shows a difference of temperature rise in favor of the softer metals. The tests in Figs. 2 and 4, in which ring feed was used, also show this same result.

Between the ball-seated and straight-seated bearings, the choice lies with the former. In Figs. 2 and 7, which show a comparison of these types, there is a difference of 8 deg., or 16 per cent., in the case of the back bearings, and 7 deg., or 20 per cent., between the front bearings.

aligning bearings. Of the latter, the babbitt-metal bearings appeared to have a greater effect in reducing vibration than those of the harder metals.

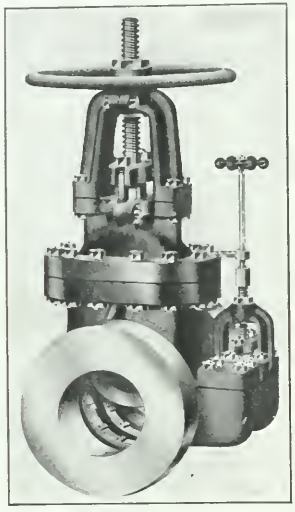
Improved Victor Gate Valve

This valve can be had made entirely of brass or iron body, brass mounted, in "puddled" semi-steel and also cast steel. The valve is made in two forms: one with stationary stem, and the other with outside screw and yoke. The seat rings, also the wedge disk, can be renewed when worn. That portion of the valve body which receives the seat rings is threaded to the correct angle of the tapers of the valve disk. The valve seats are removable. As the valves are double seated, they will take pressure from either end.

Either pattern of valves can be packed under pressure when wide open. The stuffing-box in the valve with stationary stem is screwed into the hub. The gland and stuffing-box are lined with bronze bushings, which forms a bearing surface for the stems. The disks are accurately guided in the bodies, and the guides relieve the stems of side strains, which have a tendency to wear out the

threads. The stems in both forms of valves are made of rolled tobin bronze.

The joint between the body and hub consists of grooves cut in the top surface of the valve body, in which are placed seamless copper gaskets. The valve can also be had with exterior bypass, a view of which is herewith shown. The bypass is cast integral with the body. The additional metal required for the bypass strengthens the



LUNKENHEIMER GATE VALVE WITH BYPASS

valve body; being self-contained, it is not affected by extremes of expansion and contraction. The bypass-valve trimmings are bolted to the valve body. The stuffing-box is made of bronze and has a flange on the bottom thereof, which prevents the iron flange above it from touching the iron body, and, hence, prevents corrosion between these surfaces.

The bushing, which is threaded to receive the threads on the stem, not only prevents corrosion, but also makes it possible to renew the same when worn. The area of the bypass is sufficiently large to admit enough steam around the disk to quickly equalize the pressure on both sides.

The Lunkenheimer Co., Cincinnati, Ohio, is the manufacturer of this valve.

Hydraulic "Hydro-Cator" Indicator

The "Hydro-Cator," a new hydraulic indicator, is shown herewith. It is designed to indicate the depth of water or other liquids in tanks of all kinds, reservoirs, water towers, wells, sumps, filtering plants, etc., and can be located any distance above, below or from the liquid to be indicated.

The device is manufactured by the Sterling Gauge Co., 134 East Larned St., Detroit, Mich.

This instrument is simple in construction, free from moving parts, and always shows the exact amount of water in the tanks or water towers, in inches, feet or gallons.

The contents of the tank is indicated by a brilliant-red liquid or by mercury in a glass tube. The scale reading is 10 in. high for the standard instrument, which represents the full depth of the tank, whether it is 2 ft. or 100 ft., as each gage is specially calibrated for the depth of tank and specific gravity of the liquid to be indicated. They are made with glasses, up to 72-in. readings if desired.

The instrument, Fig. 1, is fastened to the wall of an office, etc., and an ⅛-in. outside diameter capillary copper tube, annealed, and very flexible, is run to the tank either above or below the ground; it contains only air and will not freeze or stop up. One end of this hollow tube is attached to the top of a casting, 6 in. in diameter, called the compressor, Fig. 2, and is attached to the bottom and outside of the tank, or it may be lowered from the top of the tanks to the bottom on the inside.

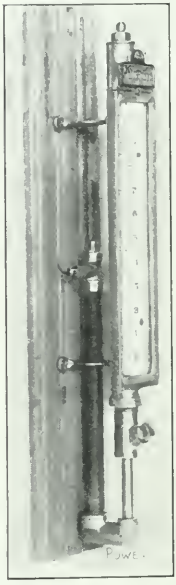


FIG. 1. HYDRO-CATOR

Static pressure of the liquid in the tank forces the trapped air in the compressor and tube line against the indicating liquid in the instrument, and causes it to rise in the glass tube in proportion to the height of liquid in the tank. It is not necessary to empty a tank of its contents when installing the apparatus. It is charged with air at any time by attaching a standard bicycle-tire pump to the cap on the top of the instrument and a few strokes of the pump will put the instrument in balance with the liquid in the reservoir. The "Hydro-Cator" will then show the depth of water in the standpipe or tank.

It serves as well to indicate the rise and fall of water

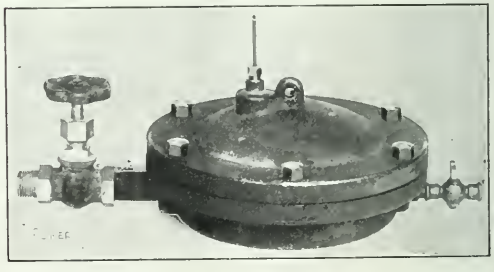


FIG. 2. COMPRESSOR

in rivers, dams and flumes and can be used for registering oils, gasoline, syrups, spirits and chemicals. It is not affected by any variation of temperature.

Fine grinding can be done with a coarse-grain wheel under the proper conditions; in the same way a fine wheel may produce rough work. Many of the scratches which appear on ground work are made by small particles of metal between the wheel and the work. Good grinding demands conditions which allow these particles to escape.—"American Machinist."

Inaccuracies of Indicators*

By James G. Stewart

SYNOPSIS—The indicator is subject to systematic errors not generally recognized. For important deductions from indicator diagrams the instrument should be calibrated for those errors. Results of experiments and description of special apparatus employed for determination of errors of indicators.

❖

[Some experiments to determine the errors to which an indicator is subject are described in the original paper, and for the purpose of presenting concrete conception of the errors both of mean pressure and shape of the diagrams the author gives a correction of the diagram of Prof. Burstall's "Crosby-Hopkinson Comparison Tests," a paper read before the Institution of Mechanical Engineers in 1909, these having been chosen because the indicating was considered of the highest order with the given instruments. Mr. Stewart's research was carried out in the mechanical-engineering department of the University of Birmingham and experimenting upon the identical indicators used in Prof. Burstall's comparison tests.—Editor.]

A consideration of the uses to which some of the most eminent engineers have put the indicator and of the far-reaching deductions made by them led to this investigation of its behavior. Professors Callendar and Nicolson, in their classic experiments on the temperatures in the steam engine, found a discrepancy between the temperature of the steam as measured directly and as calculated from the indicator diagram. The discrepancy, although small, they explained by a theory of instability of state of steam during expansion; it could be explained very satisfactorily by an error in their indicated pressures if such could be proved to exist. Professor Burstall in his gas-engine work has made much use of the indicator; he has calculated from its diagrams the temperatures of the gases throughout the expansion stroke and compared them with actual measurements of these temperatures. He has enunciated a law of cooling in the gas-engine cylinder, and supported it by the agreement of deductions made from it with the indicated form of the expansion line. Dugald Clerk, in his well known work on the specific heat of gases, has depended almost entirely on his indicator diagrams.

Prof. Bertram Hopkinson has also used his indicator to determine the specific heats of gases, and has found unexplained peculiarities toward the end of compression and beginning of expansion. The problem of the behavior of gases in a gas-engine cylinder would be much simplified if these could be explained by errors in the indicator.

In steam-engine work an almost absolute reliance is placed on the indicator diagram; from it one deduces dryness fractions of the expanding steam and draws the corresponding entropy diagrams; from which, in turn, various deductions are made of heat interchanges taking place in the cylinder. In the measurement of indicated horsepower there is not more reason for putting trust in the indicator. If through any cause a large amount of friction were offered to the motion of the pencil, the indicated horsepower would be much in excess of the true horsepower for diagrams of the usual shape.

The author's experiments lead to the conclusion that the errors in indicator diagrams are much greater than has been usually assumed. They show that there is a lag, often very great, of the pencil behind its true position, and that the error so introduced is not a constant but generally increases with the stiffness of the spring and with the pressure. These errors, large, yet not readily apparent, are not uniform but vary with different indicators and even with different springs of the same scale. Such errors and the uncertainty of their magnitude are hurtful to the progress of engineering. The indicator should either be an accurate instrument, or a ready means of measuring its errors should be devised. The methods used in the author's experiments help to make the latter alternative possible, and the results, insofar as they point out the causes of errors, will be useful to designers in their search after the former.

There is in the indicator the possibility of two distinct errors:

(1) The indicated pressure may not be that corresponding to the pressure in the cylinder, due either to friction or to inertia of the moving parts or to both.

(2) The position of the drum may not be that corresponding to the position of the piston, due to stretch of the string or to straining in other parts of the indicator gear. These will be considered separately.

In the author's experiments, Crosby gas-engine indicators, internal-spring type, fitted with heavy pattern pencil gear, were used. As the only essential difference between the Crosby gas-engine indicator and the Crosby steam-engine indicator is the diameter of the piston, the results are applicable to the steam indicator, bearing in mind that the scale of the springs must be altered in proportion.

As indicator diagrams are subject to error from many causes which are really defects of the engine and not of the indicator, it is necessary, in order to determine the errors of the indicator, to eliminate errors of the former class. In the pencil motion a chief source of error in steam-engine work is the presence of water in the indicator or in its connection with the cylinder; this has been avoided by using compressed air as a working fluid. In the drum motion, errors of design of the indicator gear were eliminated by a differential method. Further, as no satisfactory deductions on pencil motion could be made from a diagram taken from an engine, a special method was used.

Motion of the Pencil (or of the Equivalent Pressure Indicating Mechanism of the Optical Indicator)—To record the pressure accurately the pencil must have for each pressure a single definite position, and it must take this position whenever the pressure in the cylinder is that corresponding to the position. This is only approximated to in any indicator. Friction and the inertia of the moving parts introduce errors; there may also be an error due to slackness in the pins of the pencil gear, which error, however, is one which ought to be avoided. A knowledge

*Extracts from a paper entitled "Indicators," presented at the January meeting of the Institution of Mechanical Engineers, London, England.

of the friction and the inertia gives the data necessary to calculate the error in the motion of the pencil.

Frictional Resistance to the Motion of the Pencil—If a Crosby indicator be subjected to pressures represented by the line *abcd*, Fig. 1, it will be unable to follow the instantaneous change of pressure represented by *bc*, and in consequence oscillations will be set up, and the pencil will give some such indication as *abefghd*, Fig. 1. These os-

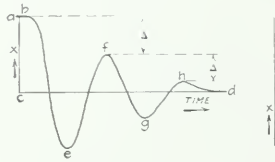


Fig. 1

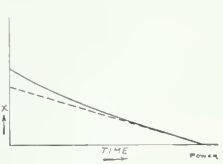


Fig. 2

Oscillations Due to Friction, and Their Average Effect

cillations will gradually die out, and experiment shows that the damping per oscillation (*J*) for each of the oscillations is very nearly constant, Fig. 1. It is slightly greater when the oscillations are large, but for general purposes this variation may be neglected. This condition of constant damping per oscillation is an indication of the nature of the friction which is damping the motion, namely, that it is "solid" friction, that is, it is of constant amount and always opposed to the motion; further, the frictional force is equivalent to $\frac{J}{4}$ lb. per in.^{2} on the piston. As the successive maximum heights of the pencil above its true position can be measured and plotted, *J* can be obtained with considerable accuracy from the slope

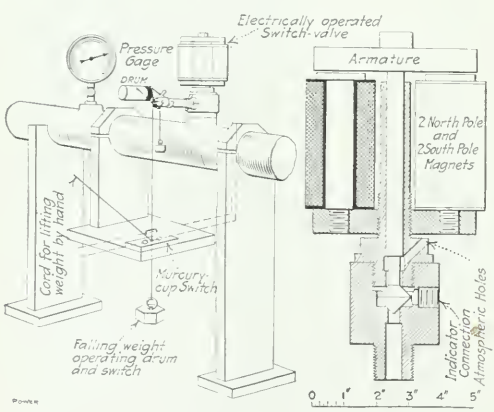


Fig. 3. Indicator-Testing Apparatus and Section of Switch Valve

of the mean curve, Fig. 2. The slope at the point at which the curve cuts the time axis gives the true solid friction. Increased slope at other points indicates the addition of a small amount of fluid damping, as shown, Fig. 2.

Experiments to Determine the Resistance to Motion of Pencil—In these the apparatus shown in Fig. 3 was used. An ordinary high-pressure air bottle had two bosses welded on; one carried a pressure gage, the other a valve of special construction. The indicator was attached to the special valve shown. This valve was double-seated. When the valve was on the lower seat, the indicator was open to the atmosphere; when it was on the upper seat the indicator was open to the bottle, which in working conditions held air under pressure. This valve was operated by a magnet which made possible a very rapid switching over of the valve, and therefore subjected the indicator to a very rapid change of pressure. This sudden change is an approximation to the instantaneous change represented by the line *bc* in Fig. 1. The drum was actuated by a falling weight; the weight in falling pulled in the fork of a mercury-cup switch, thus closing the magnet circuit and switching the indicator from the pressure air to the atmosphere. By properly timing this switch the valve could be made to act at a suitable time, and a record of the movement of the pencil was obtained on the diagram. The pressure of the pencil on the paper

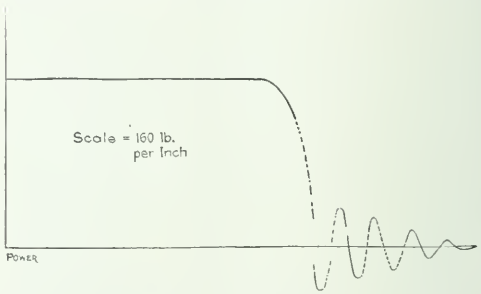


Fig. 4. Facsimile of a Diagram Obtained from Testing Apparatus

was adjusted by the screw provided, and the screw was held against the stop by hanging a small weight to it. Fig. 4 is a facsimile of an actual diagram obtained from this apparatus. It was originally intended that the switch-valve should give a practically instantaneous change of pressure in the indicator cylinder. This, however, was found impossible, but fortunately the very satisfactory oscillation diagrams obtained were sufficient in themselves to give complete information.

The frictional damping forces were calculated in terms of their equivalent pressures on the piston of the indicator; they were found to vary with change of conditions. So far pencil pressure is the only recognized variable, but other and much more serious causes of variation were found. It was only after much work that these variables were separated. Variation of the friction may be stated to be due to variation in:

(1) The pressure of the pencil on the paper.
(2) The stiffness of the spring.
(3) Different springs of equal stiffness.
(4) The pressure of the working fluid in the indicator cylinder.
(5) Different indicators.

The irregularity of the behavior of indicators is very unsatisfactory; it means that in any accurate work, indicator diagrams cannot be accepted unless accompanied by a statement of the peculiar behavior of the indicator used in taking them. With regard to past work it would be necessary, if its results are to be accepted, that the experi-

menter should get back to his original indicator and supplement his work by a statement of its errors. That error which varies with the pressure and which is due to restraining couples is the most troublesome; its presence can only be detected by some such method as that used in these experiments. The difficulty of detecting even its presence is no reason for believing it to be small. It is probably not too much to say that the indicated horsepower is frequently 10 per cent. or more greater than the true value. Dr. W. E. Fisher has called the author's attention to an engine test which shows the presence of errors of this magnitude. With diagrams of the ordinary form the effect of friction is to increase the diagram, and when this friction increases with the pressure the increase in the size of the diagram will be greater for higher initial and back pressures in the cylinder. This effect Dr. Fisher obtained by working a Willans engine: (1) condensing, (2) noncondensing; maintaining throughout the same brake horsepower. He used selected indicators and found an increase of indicated horsepower between the two cases of 3 per cent. using Crosby indicators and an increase of 4.6 per cent. using McInnes Dobbie indicators. The McInnes Dobbie indicators throughout gave much larger indicated horsepowers than the Crosby indicators; between the indicated horsepower (condensing) as obtained by the Crosby indicators and the indicated horsepower (noncondensing) as obtained by the McInnes Dobbie indicator there is as great a difference as 10 per cent. If to this be added the percentage error in the Crosby we obtain the result that the indicated horsepower as obtained by the McInnes Dobbie indicator is greater than the true horsepower by more than 10 per cent. In this experiment the assumption is made that the mechanical efficiency of the engine is constant when the brake horsepower is maintained constant, an assumption which there is much reason to believe is true or very nearly so.

It has been assumed that the friction, as measured from the oscillation diagrams, is the same as that in the indicator when the motion is that of the ordinary indicator diagram. This requires justification. It has already been pointed out in the analysis of the oscillation diagram that the friction is practically independent of the velocity; consequently its magnitude is equally great even when drawing a constant-pressure line. It is generally believed that the vibration of an engine is sufficient to relieve the indicator of all solid friction. To determine whether this was true, an indicator was fitted to a Belliss high-speed engine and a weak spring was put in the indicator. The drum was rotated by the indicator gear. The indicator cock was open to atmosphere throughout. The indicator pencil was deflected first above and then below the atmospheric line as in the Reynolds static friction test. On releasing it gently, it took a final position which even after many revolutions was almost as far distant from the atmospheric line as it would have been if it had not been subject to any vibration. With heavier springs the possibility of relieving friction by vibration is still less. The motion of the piston and pencil gear may cause additional vibration. But such was present in the oscillation experiments and its effect is, therefore, included in the friction as obtained from them. The same result was obtained on the Premier gas engine. The particular Hopkinson indicator which was tested showed errors much greater than the Crosby.

In experiments made to determine the periodic times of oscillation of the pencil, the drum of the indicator was insulated and a spark made to pass at timed intervals from the pencil point through the paper to the drum, piercing in its passage a hole in the paper. The pencil was set in oscillation and the drum rotated as in the friction experiments.

[The calculated values were found so near the experimental that for most practical cases it would appear to be sufficient to take them as accurate. Other sources of error in pressure indicating referred to in the paper are the better-known errors due to friction and which are ordinarily guarded against by careful experimenters. Among these errors the writer includes those due to: (1) Water in the connections, (2) insufficient size of connections increasing errors due to presence of water, (3) inaccurate calibration of springs, variable strength of springs depended upon for uniformity of scale and calibration at temperatures different from temperatures at which they are used, (4) slackness in the joints of the pencil gear, and (5) inaccuracies in measuring the area of the diagrams. The latter half of the paper is devoted mainly to discussion of inaccuracies of the drum motion. Error in the drum motion when flexible wire was used was found to be small and the author suggests that the error would have been very small if a stiffer and less elastic wire had been used in the straight parts of the length of the drive. Some experiments were made with short springs in the length of the driving wire. The errors in the motion were, of course, large, but there was nothing in the appearance of any one set of diagrams without comparing them with another set which would enable one to detect the presence of oscillations or errors of any kind. Referring to indicators generally the author concludes as below.—Editor.]

The design of no indicator recognizes sufficiently the necessity to insure only simple axial forces throughout the whole range of motion of the indicator piston. As workmanship can never be accepted as absolutely accurate, the design must be such that small inaccuracies in workmanship do not introduce large constraining forces and consequent large errors. Generally this will be secured by leaving the system as free as possible and in particular by arranging that no unnecessary restraint is put upon the spring or the piston. On high-speed engines the optical indicator must be used, the inertia of the drum and pencil levers being too great; even if diagrams can be taken, that is no proof of their accuracy; in fact, and more particularly with regard to absence of oscillations of the pencil, the more imperfect indicators will give the smoothest and apparently best diagrams.

Largest Turbo-Generator

The Commonwealth Edison Co., of Chicago, is soon to have the largest turbo-generator in the world. This will be a G. E. turbine of horizontal type and will be rated at 30,000 kw. It will generate three-phase, 25-cycle current, at 9000 volts and will run at 1500 r.p.m.

This will be installed in the station with the 26,000-kw. Parsons machine which the company ordered from England some time ago.

Touching upon the economies effected by the United States Steel Corporation, Mr. Farrell, its president, said that blast furnaces at Gary run 92 gas engines, which save 3,500,000 tons of coal per annum.

Steam-Loop and Gravity-Return System

By J. C. Hawkins

SYNOPSIS—An 800-hp. plant is equipped with a steam loop and gravity-return system. No traps are used in returning the condensation to the feed-water heater. The system has been in operation three years and gives excellent results.

While the theory of the steam loop may be understood, its direct application in handling condensation from high-pressure steam lines is not so well known. Herewith are illustrations showing the piping of a steam plant in which the steam loop has taken care of the condensation with good results for about three years.

The plant is of about 800 hp. capacity and has four boilers, five engines and seven pumps of various sizes. The only interruption to the service was due to replacing a split coupling and repairing a leak in a pipe.

Principle of Operation

The principle of operation of the steam loop and gravity return is simple. If a closed vessel or tank is placed above the boiler and connected to it by two pipes, one to the water and the other to the steam space, the pressure in the vessel will be the same as that in the boiler and the water in the pipe will stand at the same level as that in the boiler. If the valve on the vent pipe of the closed vessel is opened, the pressure will be lowered and water will rise in the one pipe to such a height that the added weight counterbalances the difference in pressure between the boiler and the tank, and steam will flow through the other pipe into the vessel in its effort to equalize the pressure. If the steam rising to the closed vessel holds water in suspension, the water will be swept along with the steam and discharged into the chamber where it falls to the bottom and flows into the pipe connected to the water space, thus increasing the head of water in the return line.

As the extra head of water overbalances the increase in its height, due to the difference in pressure between the boiler and the closed vessel, the water will flow into the boiler until the water in the pipe reaches its former level. This action causes the slugs of water and steam to rise from the receiver to the discharge tank, and, to further aid the system, a check valve is placed near the boiler in the return line which prevents the water from rising in the return line of the other side of the system should it be closed for any reason.

Piping Layout

In the system under discussion connections are all made to the bottom of the steam line where water can collect and the condensation is piped to a receiver below the lowest point of the line. Also a ¾-in. equalizing steam line is connected to the receiver from the header.

From the bottom of the receiver, through a 1½-in. pipe, in which long-radius bends are used in place of fittings, the water and steam rise in slugs to the discharge chamber. Entering the top of this chamber they separate, the water falling to the bottom and running to the return line. A ¾-in. vent pipe from the top of the chamber connects to the exhaust pipe through a regulating valve, and a telltale is placed in a position to be easily seen by the engineer.

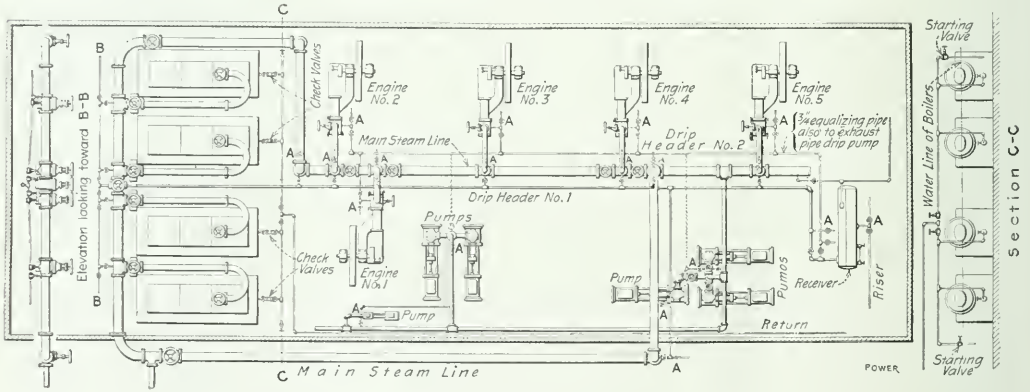


Fig. 1. Plan View of Piping

The vent pipe is to decrease the pressure in the discharge chamber as well as take out any air or noncondensible vapors that collect in the upper tank. As the exhaust is used for heating, any steam blowing through the regulating valve is not wasted. The vent pipe is not covered and any steam condensed in the pipe, by its weight, tends to lower the pressure in the discharge tank.

If the return were shut off or became stopped up, the discharge chamber would fill and water would come over in the vent pipe and be seen blowing from the telltale cock.

As shown in Fig. 1, a plan of the piping giving the location of the boilers, engines, etc., the main steam line forms a loop around the boilers and some of the engines, with gate valves, are so placed that in the event of a failure of any part of the line such part can be cut out without shutting down the whole plant, which is run 24 hr. per day. The steam line is set level and cross fittings

are used instead of tees for the branches, to the bottom of which the drip lines are connected.

Boiler Piping

The boilers are connected to the 9-in. steam line by 9x9x6-in. tees with a gate valve next to each tee and the usual long-sweep bends with an angle valve at the boiler. From the bottoms of these tees a 1-in. pipe runs to the drip header No. 1; this connection is shown in detail in section *BB*.

Valves near each connection and each side of the drip header, allow any part of the system to be cut out in case of accident to the main. A ½-in. bleeder, or "open blow" as it is called, will drain the steam from that section when repairs are necessary. On the main steam line, in the engine room, 9x9x7x7-in. crosses are used to take off the branches to the engines. To the bottom of

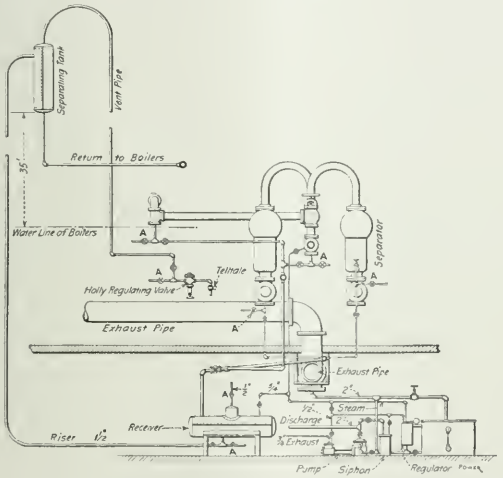


Fig. 2. End Elevation of Piping Layout

each a ¾-in. drain is connected to the header No. 1, which is placed about 1 ft. below and 4 ft. to one side of the steam main, and is hung on posts which divide the room into two bays.

Each connection is made with a nipple tee, nipple and valve with an open blow, located at all connections, as shown at the points *A*; the connections are shown more in detail in Fig. 2.

The drain from the separators, which is a 1-in. pipe above the floor, and those from the pump connections, are carried down below the floor to header No. 2, because they are lower than No. 1 header; this arrangement also brings the drips out of the way of an open blow that is placed at each connection and a valve in the line to each separator for the reasons already stated. Header No. 2 is in a trench beside the exhaust pipe.

The receiver is in a pit below the floor and the headers are connected thereto with valves for cutting out and draining either branch. This is shown in Fig. 2, which is the end view of the piping. A ½-in. vent on the top of the receiver is for blowing out air in starting, or to release the pressure for starting. A 1½-in. pipe runs from the bottom of the receiver to the discharge chamber, which is placed 35 ft. above the water line of the boilers.

The reason for locating the discharge chamber at a height of 35 ft. or over is not only to prevent siphonage, but to give a better working head. The modern tendency is to increase the height of the discharge chamber for economy in the use of steam piping. Reducing the diameter of the pipe frequently produces pressure losses which are altogether out of proportion to the small economy effected by the use of small pipe, so that the discharge losses are sometimes even higher than 10 lb. To have a safe margin of altitude, the balancing point should be preferably about half way up the return leg. It will require 25 ft. of vertical head above the boiler water line to balance, and from 5 to 8 ft. more to open the check valves and overcome frictional resistance, so that 35 ft. to the bottom of the receiver is the safe minimum and 10 ft. or 20 ft. more is taken if possible. A lower height than 35 ft. would work, if the loss in pressure between the boiler and discharge chamber is correspondingly less than 10 lb., but it is not safe.

No fittings are used in the riser, all turns being made by bending the pipe to reduce friction. The discharge chamber and pipes connecting to it are in a pipe stack and out of the way. The return pipe leads to the bottom of the tank and passes from the pipe stack near the ceiling of the engine room to the back of the boilers where it branches off and connection is made to each boiler below the water line, with a swing check valve and two gate valves in each connecting pipe. The main return and branches are all 1½-in. pipe. Section *CC* shows the return piping more fully, also the starting valves on each end of the return line, near the boilers. One starting valve is necessary, but two are placed so that with one side of the return out of commission the other can be used; this also brings the valves out of the way.

Starting the System

To start the system, all the branches into the headers are opened with the bleeders closed. Then the vent valve on the receiver is opened until all of the air is blown out of the inlet side. Then the bleeder is closed, the valve in the riser opened and one of the starting valves opened and allowed to blow until dry steam shows. Next the vent valves, the telltale and the Holly valve, as it is called, are opened; the system will then be in full operation and so continue, as long as there is steam in the pipes, without further attention. The regulating valve in the vent pipe is opened a very little and the steam escaping through it reduces the pressure in the discharge chamber, which is further reduced by the siphoning action of the water condensed in the vent pipe, but as this goes into the feed-water heater it is not lost.

The telltale, or ¼-in. pet-cock, is partly closed and blows steam into the air where it can be seen and heard. It will also blow water if the return to the boiler is closed; if the riser is closed, either steam or water will blow as long as the system is working.

In cutting a boiler in or out of service, the valves on the return line to the boiler are operated at the same time as the main stop valve, unless it is desired to use all of the condensation in one boiler. In that case all the return lines are cut out except the one to receive the returns.

Gate valves are used in this system, but if globe valves were used they should be placed with the stem in a horizontal position. Gate valves are preferable to reduce

friction. A swing check valve near the connection to each boiler prevents the water surging from one to the other, and water from the boilers backing up into the discharge tank and into the steam line. All pipes, tanks, etc., are covered except the vent pipes.

Advantages and Disadvantages

The disadvantages of this system are long lines of pipe and the height at which the discharge chamber must be located, but these are offset by a system of drainage for the high-pressure lines that is always in working order and demands no attention. It has no moving parts, requires little steam, returns the water to the boilers at a very high temperature and, if properly installed, will last as long as the steam line. The steam main may be tapped wherever there is a water pocket, thus insuring dry steam without the danger of a sudden dose of water in the engine cylinder.

The cost of operation and the results obtained are so satisfactory that after years of experience with all kinds of pumps, traps, etc., the writer regards this system as the most dependable and reliable as well as economical means of dealing with condensation in the high-pressure lines in buildings that will admit of placing the separating tank at the required height.

The exhaust line, which is below the floor, is a little different from that usually seen. A 3×4×6-ft. tank, in the sub-basement below the exhaust pipe, is connected to it by a 2-in. pipe. This tank is drained by a 2½ and 5 by 5-in. single-cylinder pump, and by a siphon in a closed chamber, which is used in case of repairs to the pump. A regulator is so connected to the tank that the height of the water in the tank controls the steam to the pump or siphon through a float and valve, thereby taking care of the exhaust condensation without loss of steam.

The pump or siphon can be run independently of the tank or regulator. This is done at present, as this pump is used as a wet-vacuum pump and, with the heating system, carries a vacuum of from 4 to 8 in.

The exhaust-pipe drip pump and connections are shown in Fig. 2. On account of the slight difference in level of the exhaust pipe, a sewer pump or trap was necessary, and of the two the pump was found the most reliable. Drips are also pumped through an oil separator, then into the feed-water heater and saved. The pump has been in constant operation over two years and has been packed only once during that time; so far it has not been found necessary to use the siphon except to try it out.

Machinery Exhibits at Panama-Pacific Exposition

Rapid progress is being made in the construction of the main exhibit buildings at the Panama-Pacific International Exposition at San Francisco. The first of the buildings is now completed and five other structures are under way. There will be fourteen main exhibit buildings in all, and contracts will be let upon the others to bring all to completion by July, 1914. Work upon the Machinery Building, the largest of the group, is advancing and the framing of the main portion of the structure is partly completed. This will permit the complete installation of exhibits by the opening date, Feb. 20, 1915. The exposition management plans a record not only in construction but in the presentation of a finished spectacle on the opening day.

The department of machinery exhibits is thoroughly organized and filings for exhibit space have been received to an extent that assures a fine display. Early applications are especially welcomed by the management and will facilitate the proper grouping of the exhibits and the perfection of other arrangements essential to the interests of exhibitors as well as to the exposition.

For the information of exhibitors the following brief data have been forwarded by the exposition company: The Machinery Building will have nearly eight acres of floor space. In addition, there will be an auxiliary structure to be known as the Gas and Fuels Building. The electrical machinery will be located in the Machinery Building and classed under the general heading of machinery.

All parts of the building will be served by adequate crane facilities. Alternating and direct electric current, gas and water will be available in any portion of the building; compressed air and steam will be provided in a section adjacent to the Gas and Fuels Building. General illumination is to be provided by the exposition company, but a nominal charge will be made to exhibitors for other utilities service they desire. Special rates for power will be made to exhibitors who use it to show machinery in motion.

The Machinery Building floor is designed for 200 lb. per sq.ft. The soil conditions will permit adequate foundations for heavy machinery to be readily constructed. No charge will be made for exhibit space.

The management urges that concerns and individuals desiring to participate lose no time in getting into touch with the company and filing applications for space.

Copies of the rules and regulations, the classification of exhibits, blank applications for space, and other information prepared for the guidance of exhibitors will be promptly forwarded on request to the Panama-Pacific International Exposition Co., San Francisco, Calif.

Bristol Revolution Counter

The revolution counter, made by the Bristol Co., Waterbury, Conn., is designed for use wherever mechanical movement is to be counted. It is made of iron and steel, according to the metal best suited to its purpose. The dials are white, with ½-in. figures in black.

The principal feature of this counter is that all the figures can be set back to zero with one turn of a key. The counter, according to size, registers, 10,000, 100,000 and 1,000,000. The casing is of polished brass.

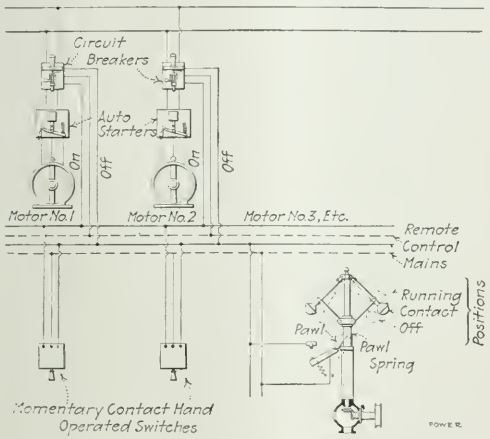
Heating a building by means of steam pipes embedded in the concrete floor has been successfully accomplished in the chassis testing building of the Moline Automobile Co., Moline, Ill. The structure is 120 ft. long by 60 ft. wide with door openings extending completely across the ends of the building. The workmen are obliged frequently to lie on the floor in making necessary repairs and adjustments and on this account, it was desired to keep the floor surface comfortably warm. To accomplish this, 1¼-in. steam pipes spaced 42 in. on centers were laid 2 in. below the surface of the 6-in. floor slab. The concrete is reinforced locally against cracking due to the expansion of the steam pipes by corrugated, galvanized iron pipes enclosing the former. Below the floor slab, 8 in. of cinder fill is placed as an insulating material. It is stated that with only five small metal radiators additional, it is possible to obtain a uniform temperature of 65 to 70 deg. Fahr. throughout the building.—"Contract Record."

ELECTRICAL DEPARTMENT

Electric Control for Conveyor Belts

By D. R. Shearer

Not long ago the writer was called upon to design an automatic control system for six interdependent conveyor belts. The conditions to be met were such that at first it seemed difficult to achieve a satisfactory result, but finally a system was developed which promises to be satisfactory in every particular.



Control Circuits Connected with Governor

Four of the belts are arranged so that each dumps onto the succeeding one, thus forming a continuous conveyor line. The other two are used alternately, both being fed by the main belt-conveyor line. The control requirements were as follows:

Should any belt stop through failure of driving power, breaking of the driving belt, overloading or clogging, the others should also stop, thus preventing the accumulation of load on the motionless belt. It was necessary also that all the belts be arranged to stop or start from any one of several points. Of course, it was necessary that the unused belt of the alternate pair should have no effect upon the operation of the remaining five.

The control system as finally designed is shown in the sketch. All the belts are motor-driven, and each drives, through a sprocket and chain from a friction roller, a special governor of the flyball type. This governor is so arranged that at a critical speed, about two-thirds the running speed, an electrical contact is closed; as the speed falls still lower the control circuit is opened, so that when the belt and governor are at rest, there is no electrical contact

Moreover, this contact is closed only as the governor slows to the critical speed and not as it is coming up to speed past this critical position: the pawl in this case slips by the switch. Thus, in starting the belts from rest to full speed no contact is made, but should any one, or all, the belts slow down to a certain speed, or stop, the control is closed.

Each driving motor is furnished with an auto-starter, and also with a remote-control circuit-breaker. These circuit-breakers not only act as switches for the remote control, but also have overload and no-voltage release mechanisms. The relay current, or current used to operate the circuit-breaker solenoids, is taken from the main feeders, but has separate fuses. For starting and stopping an instantaneous contact, three-point hand switch is used, so that relay current may be thrown on either the make or break solenoid of the circuit-breakers. The governor, however, is connected only to the solenoid which trips the breaker.

It is evident from the foregoing that should any operating belt slow down or stop, its governor will close the contact, and trip not only its own circuit-breaker, but all the others. After the cause of the stopping has been removed all the breakers may be thrown in from any of the hand switches. Should it become necessary to stop all the belts by hand, this can also be done by throwing the hand switches to the other point.

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Water Rheostats

By R. L. Daugherty

In some recent testing it was necessary to construct a water rheostat to absorb the power from a 2200-volt, three-phase, 150-kw. generator. It was also desired to overload the generator up to about 210 kw., which meant a maximum current of about 60 amp. per phase. On account of the high voltage, ordinary water was sufficient and the rheostat was suspended in a creek running alongside the power house.

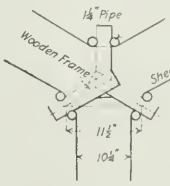


Fig. 1. Plan of Rheostat

Fig. 2. Sheet before Being Bent

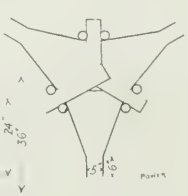


Fig. 3. Rheostat after Alteration

There was little information to be had upon rheostats of this type, so the first one built was in the nature of an experiment. For each of the three terminals, two pieces of 1¼-in. pipe, 3 ft. long, were screwed into a return bend with a back outlet. In the back outlet was placed a pipe plug with a hole drilled for the wire, which was held by a setscrew. These pipes were suspended from a wooden frame and each pair was placed at the vertex

of an equilateral triangle having 15-in. legs. It was found upon test that when the pipes were immersed 6 in., 10 amp. per phase was absorbed. When immersed 24 in., only 22 amp. per phase was absorbed, giving a total power consumption of about 80 kw. As 2 ft. was the greatest depth of immersion that could be obtained at a convenient spot, the rheostat had to be rebuilt.

This time the pipes were placed a little closer together, the leg of the triangle being reduced to $11\frac{1}{2}$ in. (See Fig. 1.) In addition, a piece of No. 24 sheet iron of dimensions shown in Fig. 2 was bolted onto each pair of pipes, holes being drilled in the latter for that purpose. This sheet was then bent back to form an angle of 120 deg. so that each adjacent pair of sheets were parallel.

FIG. 4. RHEOSTAT SET UP IN CREEK

The point of the sheet was put 5 in. above the end of the pipes so that a light load could be easily obtained.

When the rheostat was immersed 2 ft., as before, 52 amp. per phase was absorbed. As this was not sufficient the plates were bent to bring them closer together, as in Fig. 3. A current of 60 amp. per phase could then be obtained with a 16-in. immersion.

The framework supporting the pipes was suspended from a tripod set up in the creek, as shown in Fig. 4.

For testing a 110-volt, direct-current machine of 30 kw. capacity, it was desired to construct a rheostat which would offer enough resistance to consume 60 amp. or less and which could also consume as much as 300 amp. It was decided to use iron wire as a resistance and keep it cool by immersing it in the creek.

This was impossible to calculate with any exactness because no one could tell what the temperature and hence the resistance of the wire might be under the conditions. Two light wooden frames were made that were 3 ft. long and 11 in. square. One of these was wound with 60 turns of No. 10 and the other with 60 turns of No. 14 galvanized-iron wire. That made 220 ft. of each size. It was found that these two frames in series offered more than enough resistance for our purpose. This resistance was reduced by tapping in at different points until fairly large values of current were reached. The two frames were then placed in parallel and then the two were cut down simultaneously. The heaviest current carried was 240 amp. and for that we had 59 ft. of No. 10 in parallel with 77 ft. of No. 14. The expected 300 amp. was not obtained because the waterwheel being tested was not able to run the generator at its rated capacity.

Care and Operation of Commutators

The article by H. S. Page, in the May 20 issue, is very instructive to the average operating engineer or electrician. The writer has charge of a number of machines, two of which are compound-wound, 8-pole, 300 kw., 600-volt, direct-current generators running at 220 r.p.m. The two units are duplicates and are used for street railway service, the load fluctuating from 0 to 150 per cent.

The commutators are 30 in. in diameter with a 6-in. face and are fitted with eight brush-holders of the box type, two brushes per holder. We were first troubled with squeaking chattering brushes and the commutators were frequently lubricated with engine oil or vaseline, but this gave us trouble by destroying the mica between the segments at the outer edge of the commutator.

We tried several grades and makes of carbon brushes but they would soon begin to chatter and spark and burn the commutator. After setting the brushes in oil for a time they would do nicely for a few days after which the same trouble would begin again.

The brush-holder and brush adjustments were gone over time and again with no improvement. We tried slotting the commutators and this helped for a while but at intervals the troubles would occur without any apparent cause. We then tried a good grade of graphite brushes and this did away with the chattering and squeaking but after they were in use for some time they would get very hot and particles of the brush would adhere to the holders and cause them to stick and spark badly. The brush would not touch the commutator but this could scarcely be detected by the eye. By going over the brushes and commutators again the troubles would disappear for some time. Later we installed a motor-generator set to operate between the direct-current and alternating-current systems so that either system would help out the other.

Next we tried alternate sets of carbon and graphite brushes. This made the positive brushes graphite and the negative carbon or *vice versa,* then the graphite brushes would get hot and stick and spark. We then placed one carbon and one graphite brush in each holder with the graphite brushes in the positive holders on the outside, but this part of the commutator soon became so badly burned that it required frequent turning. We, therefore, put the carbon brushes in the positive holders on the outside but the inner part of the commutator would burn away and require turning the commutator.

We discontinued slotting the commutator but this did not help, so we then placed two graphite brushes, one positive and one negative, on the outside and carbon brushes inside, and in the next two holders carbon brushes on the outside and graphite inside and so on around the commutator. Since placing them this way we have had very little trouble.

C. E. NYE.

Morgantown, W. Va.

GAS POWER DEPARTMENT

Cylinder Heads of Horizontal Single-Acting Motors*

By Max H. Müller

At the beginning of stationary-motor development a great variety of cylinder-head patterns prevailed, but a very simple form is now gaining ground. Both theory and practice teach that simple, compact forms are useful because they favor rapidity and completeness of combustion. The Güldner design has been of great influence in this respect, and its type of simple coherent combustion chamber with central ignition has been carried from the vertical to the horizontal engine.

In the gas engine there must be a quick passage of the flame from the place of ignition through the combustion chamber, the charge having been already prepared by mixture and compression; while in the oil engine there must be a rapid impregnation of all the air with the sprayed fuel. On one hand, a very small compression chamber is necessary in order to attain the required degree of compression, while on the other, there must be provided valve ports corresponding with a high piston speed. Also, in spite of these openings, the inner combustion chamber must be made strong enough, and the cylinder head elastic enough to follow without fracture the distorting forces that act on it between combustion chamber and cooling jacket.

Since these imposed conditions are in part conflicting, a compromise is necessary. It would be preferable, from the viewpoint of cheapness in manufacture, to have a form of cylinder head which, as in the case of the vertical motors, best exemplified in the Güldner, could be used not only with the ordinary liquid and gaseous fuels, but also with heavy oils as in the Diesel or constant-pressure process.

Of late, the Augsburg-Nürnberg Co., in Germany, has taken the lead in introducing a form of combustion chamber similar to that shown by Fig. 1, except in the design of the flanges. According to the form of attachment, which varies in different factories, it consists of studs which are either screwed into the connecting flange of the frame and hold the flange of the cylinder head, Fig. 2, or *vice versa*, or are screwed into the flange of the frame and pass through the whole length of the cylinder head, Fig. 3. These various methods of attachment are of differing worth and indirectly they are probably to blame for many cracks in cylinder heads of horizontal oil motors.

Aside from cracks of characteristic form and position that result from cooling strains of the metal in casting, may be distinguished all those which occur in the inner combustion chamber or in the cooling jacket. The former are generally due to insufficient thickness of the wall of the combustion chamber or to irregular distribution of the material by displacement of the core. In part, such cracks are also attributable to insufficient stiffness of the front head, which may be distorted when subjected to the high pressures. This refers primarily to those designs in which the back wall of the cooling jacket is formed by a cover bolted on (Fig. 4) and where consequently the springing cylinder head is unsupported by the cooling jacket.

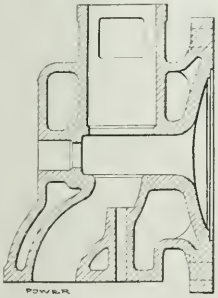


Fig. 1

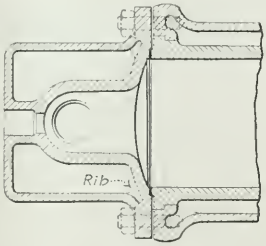


Fig. 2

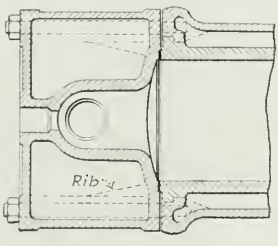


Fig. 3

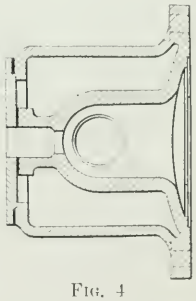


Fig. 4

In order to resist such effects, which sooner or later, either by accidental strains or by fatigue of the material, must lead to fractures of the inner combustion chamber, it is important to make the front wall so strong that, even when the core is displaced, the weakest part will withstand breakage. Also, it should be sufficiently rigid so that the elastic flexures undergone at every impulse, will be as small as possible; these results to be accomplished without depending upon the cooling jacket to sustain the tensile forces and without greatly affecting the cooling operation by inordinate thickness of the cylinder-head wall. This requirement is best filled by supporting ribs which connect the outer part of the head with the cooling jacket. See Figs. 1, 2 and 3.

Besides the formation of such cracks in the inner combustion chamber, attributable to defective material or to faulty stiffness of the head, cracks very often are found in the seats of exhaust valves. This happens more fre-

*Translated from "Der Oelmotor."

quently in gas engines than in oil engines, due very often to neglected and corroded valves and seats which have been working with dirty producer gas.

It is very essential that there be a uniform distribution of material about the exhaust-valve seat and also the greatest possible effect of the cooling water on the seat from the outside. The latter point requires that the walls shall not be too thick and further, in large engines, that there shall be a maximum withdrawal of heat from the exhaust-valve cone by a well cooled valve-stem guide bushing, or for large cylinder heads, by an independently cooled exhaust valve.

More numerous and harder to avoid than defects of the inner combustion chamber, are cracks in the water jacket, especially of constant-pressure horizontal engines. Undoubtedly the cracks are generally caused by expansion of the combustion chamber. The heat of combustion which strikes the inner chamber of the cylinder head at each impulse, expands it, while the water-jacket temperature remains comparatively low and the combustion chamber tends to distort the water jacket at the place where it is attached. Thus tensile and bending stresses and transverse forces arise in the outer jacket and lead to cracks, and the properties of cast iron are very ill suited to sustaining such stresses. Moreover, strains of unknown magnitude and form remain in the casting from the foundry.

Therefore, to prevent subsequent cracking in service, by relieving the casting strains, it is necessary that cylinder heads of horizontal motors should be annealed, as has long been the practice with vertical ones.

Of transcendent influence, however, is the question of design. This must, at the start, eliminate all connections between combustion chamber and cooling jacket that are not absolutely indispensable. Furthermore, the lever arm of flexure—the distance between the jacket and the combustion chamber—should be as great as possible in order that the change of form may be a minimum. Care must also be taken that the joint flange contains no large masses of material and is as thoroughly cooled as possible.

This last point is often neglected, but it is easy to perceive that if the thick, and only slightly cooled, joint flange expands under the higher temperature more than the jacket to which it is connected, it must loosen and crack at the joint, as is evidenced by the fact that cracks of the jacket almost always occur close along the flange. At this place the axial effects of the external forces and of the inner tensions, with the radial stresses at the flange, are, to a certain extent, accumulated to form very considerable main stresses. It is also important to avoid abrupt transitions between the jacket and flange and further to provide a minimum distance between packing surfaces and the bolt circle.

This last condition is usually hard to meet simultaneously with the others, since the packing surface must naturally be as near as possible to the combustion chamber in order that the load on the studs shall not be too heavy. This, however, for a large jacket diameter, necessitates an increased distance from the bolt circle, which, when using thick flange bolts, results in an inordinate stress on the jacket when they are screwed up hard.

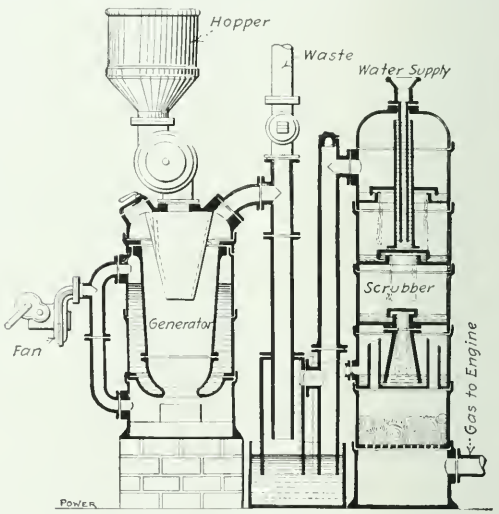
If all conditions are to be complied with as well as possible, then, after the pattern of vertical motors, the jacket should be increased to the flange diameter and the strong studs should pass through the inside of it, as in Fig. 3. This expedient has the advantage that the jacket can be held together very firmly by the tension of the studs.

Cylinder heads of this form, while retaining the well proved coaxial position of inlet and outlet valves, have lately been employed on horizontal Diesel motors of the Erfurter Maschinenfabrik Franz Beyer & Co., of Erfurt, Germany, and it may be assumed that this design, which had already been tried on small Deutz gas engines, will also be justified for horizontal Diesel motors.

The Warwill Producer

By James A. Seager

With the usual suction-gas plant in which a firebrick lining is used, trouble frequently arises in connection with the lining, and the efforts of the manufacturers have been to make the lining as homogeneous as possible.



Section through Producer and Scrubber

Moreover, after running the producer for some hours, the lining, in direct contact with the fire, is apt to become partly fused and form clinker, decreasing the gas-making area and preventing the plant from working at its full capacity. Hence a type of generator which does not depend upon a firebrick lining deserves attention. This is not new and untried, but has stood rigorous tests both as regards efficiency and life. Such a producer is built by the Warwill Engineering Works of Abertillery, Eng., and, although employing the same principles as adopted in most gas plants, embodies some unusual features of construction, which are illustrated in Fig. 1.

The furnace lining is of cast iron, entirely surrounded by a water jacket, which also forms the vaporizer. This, besides serving to supply the necessary steam, also keeps the temperature of the lining sufficiently low to prevent the adhesion of clinker. Moreover, since the lining is of cast iron, and is always kept at a comparatively low temperature, it does not burn away, thus minimizing repairs

and renewals. A further point of importance is that air leaks are practically eliminated.

In order to secure so far as possible continuous working, even in the smallest sizes of plants, the makers employ a movable cage into which all clinker gravitates and is removed through the door of the generator. This has the effect that the fire is always kept clean and bright; an essential feature in plants that are required to run continuously for long periods.

Reference to the illustration shows that some radical differences exist between this type and some of the more common forms as regards the scrubber. In the ordinary coke-packed scrubber there is a tendency for the interstices to become filled with foreign matter, such as grit, dust, particles of tar, etc., and the coke has to be renewed at frequent intervals, often involving stoppage of the plant. Moreover, about 60 per cent. of the volume of the scrubber is taken up by the coke itself, the remainder, less than one-half the total capacity, being available as gas space. The resistance offered by the coke-packed scrubber is never uniform, but is continually increasing, owing to the accumulation of dirt and dust on the surface of the coke. Frequently, owing to the presence of free ammonia and sulphur compounds, the odors arising from coke scrubbers have been found objectionable.

The scrubber is arranged in a series of water seals, kept in constant agitation by the suction of the engine, and in this way the impurities taken from the gas are not allowed to deposit in the scrubber, but are washed from each division into the one immediately below it, until eventually by means of the overflow they leave the scrubber.

The plant throughout is made of a special mixture of cast iron, the uncombined carbon of which is found to resist corrosion much better than the combined carbon of mild steel. Both the scrubber and generator are built in short sections, and occupy very little ground space.

Up to the present the average life of the Warwill plant has not been determined. Whether the makers can furnish any information on this point remains to be seen, but it is stated that there are plants working today which were erected the latter part of 1907, and have not needed extensive repairs or renewals.

Cleaning Blast-Furnace Gas*

By Fred H. Wagner

With practically the same character of apparatus—first, dry-dust cleaners; second, some sort of static towers like the Czchokke or Steinhardt, and, finally, the Theisen washer, the cost of the final cleaning varies between 15 and 62c. per 100,000 cu.ft. of blast-furnace gas cleaned, this being based on $10 per 1,000,000 gal. of water and one cent per kilowatt-hour. Why such discrepancies should exist is difficult to explain. For instance, at one of the corporation plants, the final cleaning, based on 100,000 cu.ft. of gas costs 61c., at another 17c., a third 25c., at another 20c. and at still another 15c.

Mr. Sampson mentioned that some new apparatus, which is along the line of mechanical disintegrators, claimed to use about 20 gal. of water per 100,000 cu.ft. of gas, for the whole cleaning process, and to operate on less power than the Theisen washers. He also stated that with the present process from 90 to 100 gal. are used for the entire cleaning process. Besides the Theisen washer mentioned by Mr. Sampson, there are two others, which are attracting a great deal of attention in Europe in connection with this process, namely, the Schwarz washer and the Feld washer. These both require less power than the Theisen washer, but the Feld requires considerably less power than the Schwarz.

At the blast furnaces in Donawitz, where 1,600,000 cu.ft. of gas is treated per hour, the total power with the Schwarz washers amounts to from 124 to 128 hp. At the blast furnaces in Pompey, France, of the same capacity, the Feld washers use from 50 to 55 hp.; this power includes that necessary for the exhausters.

Each section of the Feld washer contains a series of perforated truncated cones, the lower ends dipping into the water, and by the revolving of these cones, giving a peripheral speed of 1600 ft. per min., the water is carried up inside the cones and hurled out of the perforations in a finely divided spray.

In the blast-furnace plant at Pompey, France, where the Feld washers are also in use for cleaning blast-furnace gas for gas-engine purposes, prior to the use of the Feld washers, it was necessary to open the valve chests on the engines about once every ten days and remove the accumulated dust; since the installation of the Feld system, it has only become necessary to open the valve chests about once every three months. These washers have been in continuous operation for about 30 months without a shutdown for cleaning or repairs—the washers being self-cleaning, the water carrying the dust, leaves the washer in the form of thin mud, which is easily handled by centrifugal pumps.

*Discussion of Mr. Sampson's paper on "Operating Gas Engines Using Blast-Furnace Gas," which was presented at the spring meeting of the A. S. M. E. and printed in abstract in last week's issue.

Gas-Engine Piston Troubles

Recently the writer was called in to examine a gas engine of the horizontal type, which the operator said was trying to knock its cylinder head out. It was found when opening up the cylinder that the rings were kept in place by an ordinary junk ring held by eight ⅞-in. studs, one of which had dropped out, and had been pounded to pieces. This had driven one of the other studs into the junk plate, splitting it and breaking out a large piece.

As this engine ran a small mill, it was necessary to have it running at the earliest moment. We obtained a spare junk ring from the makers, which had to have all the holes plugged and fresh ones drilled. When it came to putting the junk back, it was found that all the studs were loose in the piston head, and as one could not be obtained locally, as a last resort they were dipped into thick boiled oil, which kept them tight until the arrival of a new set, when, judging from the trouble in removing, they would have lasted much longer.

From observations on a number of gas-engine pistons fitted with junk plates, the writer has found a tendency for the screws to work loose, which, after all, is not to be wondered at when the great changes in temperature are taken into account. This refers to noncooled pistons.

E. Russell Pearce.

Rochdale, England.

HEATING AND VENTILATION

Rates and Regulations for Central-Station Hot-Water Heating

In its controversy with the Toledo Railway & Light Co., the public service commission of Ohio has issued an important decision prescribing rules for determining the amount of radiation required, rates for service, and the specifications to be met in such service. The new schedule issued by the commission is to go into effect Sept. 15, 1913, and should have its influence on the central-station heating industry in the state.

For determining the square feet of radiation required to heat a building, the following rule is to be used: Determine the area of the exposed walls in the building. From this subtract the area of windows and door openings (frame measurements). This remainder should be divided by the wall constant given in Table 1, and to the result should be added the area of window and door openings (frame measurements). This sum should be

TABLE 1 WALL CONSTANTS

For 1-in. wall	1
For 2-in. wall	2
For 4-in. wall	3
For 6-to 9-in. wall	5
For 9-to 10-in. wall	7
For 13-to 27-in. wall	8

TABLE 2. TEMPERATURE CONSTANTS

For 65 deg. F.	0 0075
For 70 deg. F.	0 0082
For 75 deg. F.	0.009

multiplied by 75, and to this result should be added the cubic contents of the room. Multiplying the sum last obtained by the temperature constant given in Table 2, will give the square feet of cast-iron radiation required to heat a building of good construction. Any room or space having an opening which may communicate with the rooms to be heated must be included in the measurement for space heated, whether radiation be installed or not.

The rule is for ideal conditions and to the radiation requirement determined by its use, there must be added a percentage to provide for exposed locations, bad construction, insufficient or improper repairs and other conditions which would make the minimum radiation requirement inadequate to keep the building comfortably warm. For these conditions which cannot be ascertained by general rule add from 5 to 25 per cent. to the minimum for ideal conditions.

It is specified that the heating company must furnish hot water in sufficient quantity to heat the building to a temperature of 70 deg. F. in the coldest weather, provided that sufficient radiation be installed by the consumer to maintain the desired temperature. Evidence of the sufficiency of the quantity of water shall be that the temperature of the hot water has not dropped more than 30 deg. F. while passing through the consumer's heating system, as shown by not less than four tests taken 15 min. apart in succession, the tests to be made at the point of entrance of service to the building.

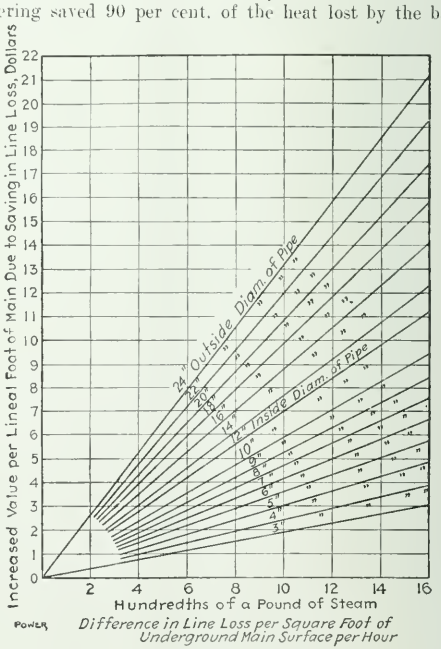
Surface area of all hot-water pipes installed in the basement or elsewhere not included in the measurement for radiation will be charged for as radiation, unless covered with at least 1-in. covering. The following rates were ordered to be put into effect:

Amount of Radiation Installed	Cost of Radiation per Season, per Sq.Ft.
0 to 500	$0.20
500 to 2000	0.1888
2000 to 5000	0.1777
5000 or over	0.1666

For indirect radiation 10 per cent. of the above rates are to be added.

Efficiency of Underground Steam Mains

In a paper read before the annual meeting of the Engineering Society of the American District Steam Co., Byron T. Gifford defined the efficiency of a pipe covering as the percentage of heat saved by using the covering. For example, 90 per cent. efficiency would mean that the covering saved 90 per cent. of the heat lost by the bare



VALUE OF EFFICIENT INSULATION

pipe. The line loss in underground steam mains varies from 0.4 lb. or less of steam per square foot of pipe surface per hour in the most efficient construction to 0.14 lb. or more per square foot of surface with insulation of inferior quality.

To show the advantage of more efficient covering, the author took a concrete case with the following assump-

tions: Square feet of surface in the mains and services, 13,423; capacity in pounds of steam per hour, 30,000; average selling rate per thousand pounds of steam, 55c.; hours in heating season from Oct. 1 to June 1, 5832.

The accompanying table gives the pounds of steam required per season for the system outlined above, with insulation of different qualities covering the piping:

Insulation	Pounds Steam per Season	Line Loss in Dollars
No. 1 Line loss at 0 04 =	3,131,316	$939
No. 2 Line loss at 0 05 =	3,914,147	1173
No. 3 Line loss at 0 06 =	4,696,874	1409
No. 4 Line loss at 0 07 =	5,479,806	1644
No. 5 Line loss at 0 08 =	6,262,632	1879
No. 6 Line loss at 0 09 =	7,045,463	2113
No. 7 Line loss at 0 10 =	7,828,294	2348
No. 8 Line loss at 0 11 =	8,611,021	2583
No. 9 Line loss at 0 12 =	9,393,748	2818
No. 10 Line loss at 0 13 =	10,176,680	3053
No. 11 Line loss at 0 14 =	10,959,612	3288

The line loss in dollars given in this table was computed on a basis of 30c. per 1000 lb. as the generating cost of the steam. From these data it is easy to compare the saving of one insulation over the other, for example, by using No. 1 instead of No. 8 a saving in line loss of $1644 will be effected.

It is generally recognized that a good pipe line will last about 20 years, so that for depreciation 3½ per cent. (sinking fund) of the investment would be charged. Allowing 5 per cent. for interest it is plain that a fixed charge of 8½ per cent. on the investment must be paid every year. To calculate the amount it would be advisable to spend for efficient covering the fixed charges (interest and depreciation) on the additional investment should be compared with the decreased income due to greater line loss. By using No. 1 instead of No. 8, the insulation will save $1644 per year. This is 8½ per cent. of $19,341.20 and anyone would be justified in paying this additional sum for the 13,423 sq.ft. of underground pipe surface, that is, No. 1 insulation on the piping is worth $19,341 more than No. 8 insulation.

Under these conditions the eventual saving per square foot of surface is

$$\frac{\$19,341}{13,423} = \$1.44 \text{ per sq.ft.}$$

The line loss for No. 1 insulation is 0.04 lb. steam per square foot per hour, the line loss for No. 8 is 0.11, making a difference in line loss of 0.07 lb. of steam per square foot per hour. For each 0.01 lb. of steam it is then possible to save per square foot of surface per hour, $1.44 ÷ 7 = 20.6c. Calling this figure 21, it is not difficult to properly classify and value different styles of insulation.

Take, for example, 1000 ft. of 8-in. line. To compare two insulations, one with a line loss of 0.05 lb. per hr, and one with a line loss of 0.11 lb. per hr., the difference being 0.09 lb., the following expression may be used:

$$n \times s \times L \times 21c.$$

where

n = Hundredths of pounds of steam lost per square foot;

s = Surface of the pipe per lineal foot;

L = Length of line;

21c. = Constant based on 30c. per 1000 lb. of steam, 5832 hr. per season.

Substituting in this formula the values in the above example gives:

$$9 \times 2.25 \times 1000 \times 21 = \$1252.50$$

This shows that $1.25 per lineal foot of 8-in. line is the increased value of the more efficient insulation. The accompanying chart, which shows the value of efficient insulation on pipes of different diameters, was based upon this formula. As an example in the use of the chart, take a 12-in. pipe line when the difference in efficiency is 0.08 lb. of steam per hour. Find 8 on the horizontal scale and follow this line up to the 12-in. line, then follow horizontally to the left and find that the difference in value is $5.61 per lineal foot.

Coal Required for Heating

In the issue of Apr. 15, W. L. Durand gave a preferred rule for estimating the amount of coal required during the heating season, and also made some objections to three rules used in New York City for the same purpose. Mr. Durand showed that for pea coal of 12,000 B.t.u., 78.75, or practically 80, lb. per sq.ft. of radiating surface per season would be required. The three rules to which he objected were as follows:

1. *Grate area multiplied by 4.4 equals tons of coal burned per season.*

2. *Each cubic foot of contents will require 0.9 lb. of coal per heating season.*

3. $$\frac{\frac{\text{Exposed wall surface}}{4.5} + 2 \times \text{glass surface}}{100} = \text{tons of coal per heating season}$$

Some interesting data bearing on these rules have been submitted by the engineer of a large department store in Chicago. The building has a contents of 18,000,000 cu.ft., a wall surface, exclusive of glass, of 240,000 sq.ft., a roof area of 99,000 sq.ft., and a glass surface of 240,000 sq.ft. The building is heated entirely by live steam, and is equipped with 160,000 sq.ft. of radiation, which to the volume bears a ratio of 1 to 112.5.

Rule 2 allows 0.9 lb. of coal per cubic foot. Thus, $0.9 \times 18{,}000{,}000 = 16{,}200{,}000$ *lb.* = 8100 *short tons.* Averaging the five years 1908 to 1912, inclusive, the actual coal consumed was 7250 tons. It should be mentioned, however, that about one-sixth of the volume given above is in the basement and sub-basement, which require less heat than the space above ground. Assuming that only 50 per cent. of the heat per unit of volume is required and figuring the entire building as above ground, it would bring the coal consumption up to 7855 tons, as compared to the 8100 tons given by the rule. As a rough approximation the rule appears to give results very close to the actual in this particular case.

In Chicago, a constant of 1 lb. instead of 0.9 is often used, and naturally, as it is colder there than in New York City, and the heat value of the average coal is lower.

Adding the roof area to the wall surface of the store gives 339,000 sq.ft.; then substituting in Rule 3,

$$\frac{\frac{339{,}000}{4.5} + 2 \times 240{,}000}{100} = 5553 \text{ tons}$$

This value is considerably lower than the actual tons of coal burned.

Taking the actual coal consumption of the building and dividing by the square feet of radiation, gives:

$$\frac{14{,}500{,}000}{160{,}000} = 90.6 \text{ lb.}$$

of coal per square foot of radiation. This is a little higher

than the 38.75 given by Mr. Durand, but might be expected, due to the colder climate and the poorer quality of coal generally used in Chicago.

A small factory building, 100x100 ft. and 90 ft. high, with windows in the two ends and the side walls blank, used 250 tons, or 500,000 lb. of coal. The cubical capacity of the building is 900,000 cu.ft. By Rule 2 it would require 405 tons, and by Rule 3, 235 tons of coal, the latter being nearly correct.

From the foregoing it would appear that Rule 2 is correct for large buildings and incorrect for small structures; while Rule 3 is just the reverse. It must be borne in mind, however, that the contributor who sent in the above data has taken two buildings representing extreme cases and they may be the proverbial exceptions that prove the rule.

The figures given are averages and not absolutely correct. It would be interesting to hear from other readers of POWER as to how these rules check with results obtained in their plants.

Live-Steam Connections to Exhaust-Steam Heating System

The Apr. 15 issue of POWER contained an article by Charles H. Bromley entitled, "Some Troubles of Steam-Heating Systems." In the second paragraph the author suggests a method of connecting the live- and exhaust-steam mains to avoid excessive use of live steam for heating. I overcame the same trouble in another manner which I believe simpler and more economical.

The system, using exhaust steam at ½ lb. pressure was

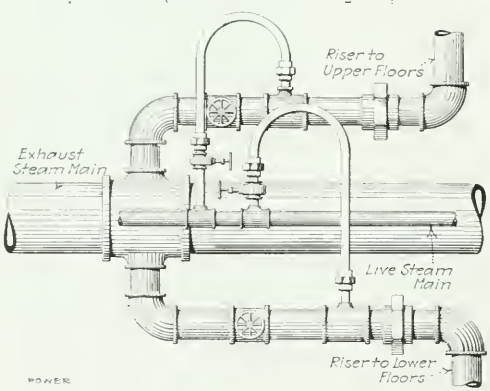


FIG. 1. TYPICAL CONNECTIONS BETWEEN LIVE-STEAM HEATING MAINS AND EXHAUST

installed in a six-story and basement factory building, the live and exhaust mains being horizontal were installed on the third floor of the building, extending around on all four sides near the walls and hard against the floor beams. From the exhaust main vertical risers were run to the upper and lower floors to ordinary pipe coils, each coil being controlled by a valve between the riser and coil. The returns were connected to a common riser, one on each side of the building and these in turn were connected to a horizontal return in the basement and this connected to the feed-water heater.

The live-steam main, 1¼ in. in diameter, was located alongside of the exhaust main, as shown in the accompanying sketches. The feature is the connection between the live and exhaust mains, as shown in Fig. 1. The connections are ½-in. pipe bends, with valves located, as shown, to control the flow of steam.

This arrangement admits no live steam into the exhaust main, except when desired, and gives control of the

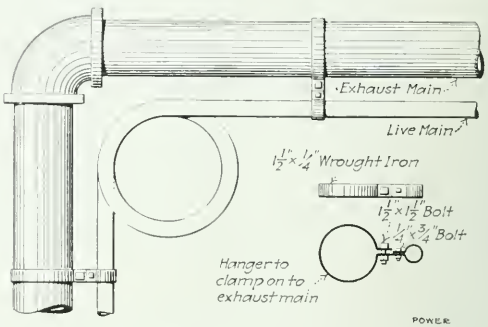


FIG. 2. LIVE-STEAM PIPE CLAMPED TO EXHAUST MAIN

steam so that it can be directed to any coil or coils in the system independently of all other coils.

An additional feature of the live-steam main consists of a loop or pipe bend, as shown in Fig. 2. This allows for expansion without an expansion joint and also obviates water-hammer. The method of hanging the live-steam pipe to the exhaust main is also shown in this sketch.

This system has been in constant use for more than six months and is giving perfect service.

B. R. LEEDS.

Philadelphia, Penn.

Commission Control of Public Utilities

Satisfactory rates and good service would be the rule if all utilities held the same views as D. L. Gaskill. Following are a few paragraphs from his paper read before the National District Heating Association, at Indianapolis:

"The State Utility Commission, appointed by the highest power of the state, with jurisdiction over the whole of the state, opened up the way for the solution of the trouble between the people and the utility. After a few years' experience with the state commissions when they have been given ample funds and power, most of the ill feeling and distrust existing between the utility and the public has disappeared and a feeling of coöperation and confidence has taken its place.

"Under the so called home rule doctrine that is being put forward in some states as a progressive step, the value of utility control is in grave danger of being destroyed. Local control of utilities will have neither the power nor knowledge to prevent duplication of plants and will be generally subject to the popular but false idea that competition in utility service brings low prices. Where there is state utility control, sufficiently complicated to draw broad-minded men to its service, such errors would not be permitted.

"Under intelligent state control, we may expect eventually to have all the intricate problems of utility management worked out to a standard.

EDITORIALS

Government Plants

The government is showing increasing interest in the central-station and the isolated-plant question. Secretary of the Treasury McAdoo has awarded the contract for an installation to furnish heat, light and power for the federal building in Chicago, in which the post office is located. This is a consequence of an expert investigation, which revealed that a saving of ten thousand dollars a year to the government was possible. It is a source of gratification that the central station, which had been supplying the current for light and power, could not hold the business even by offering a rate far below what it is charging other Chicago consumers and wielding all the political influence it could bring to bear.

The success and economy of the plants already in use in government buildings seems to have decided the Secretary to extend the system of government plants to other large structures. If this is so, the State House in Trenton deserves attention. There a plant nearly large enough to run the building remains idle with all the standing charges against it, and men enough to run it are employed to run the boilers for heating and nearly, if not quite, coal enough to run it is burned under the heating boilers, while the State of New Jersey pays the Public Service Corporation six cents a kilowatt-hour for current.

Colliery Boiler Plants

While there are some exceptions, the power plants of most collieries do not compare favorably with those found operating manufacturing establishments. This applies particularly to the boiler room where operating conditions are far from ideal. Many such installations are very dirty with coal strewn thickly over the floor and ashpits nearly full of ashes. When the ashpit is cleaned out, but scant attempt is made to prevent mixing good coal with the ashes and throwing all out together. Then, again, neglect is indicated by the cracked condition of the boiler settings, especially where return-tubular boilers are used, and by badly cracked furnace fronts and warped fire-doors. Many of the latter are so out of shape that it is impossible to shut them tightly.

Leakage of air through the cracked boiler setting into the combustion chamber and an excessive amount of air leakage past the furnace doors above the fires produces but one result, improper combustion.

If the exteriors of the boilers show neglect, it is natural to assume that the interiors are no better, and, if so, many of them are evidently operating under dangerous conditions. The few colliery plants operating without this neglect of economy and safety, for some are kept clean and orderly, by contrast, reflect the greater discredit on the rest.

Reasons for this state of affairs are cheap coal, indifference, ignorance and lack of opportunity. The first three probably have much more to do with the effect than the last named.

None of these reasons is sufficient to excuse the situation. Even if the coal is cheap, it is worth as much in the plant coal bin as on a car ready for shipment. If a ton of coal is worth a dollar when ready for the market it is worth a dollar in the boiler room. Every ton of coal needlessly consumed in the boiler furnace is a dollar thrown away.

Let a good fireman ask for a ten-cent increase in wage and the probabilities are that his request will be refused. Let him needlessly waste a ton of coal and nothing is said.

How do you account for this Mr. Superintendent? Is it not because the one item will show on the operating charges against the plant in dollars and cents, while the other is charged against the plant operation as just coal?

An increase in the selling price of coal is maintained by the mine operators as justifiable, because of the increased cost of production, but has any attention been given to the economical operation of the power plant, which produces the steam and power necessary as an element in economical production? We believe not in a large number of installations.

Is not the boiler plant left in the hands of men who are coal handlers rather than men capable of keeping the boilers in proper condition? Although neglect plays an important part in the conditions existing in so many of these mine plants it would appear that ignorance regarding boiler economy and safe operation is largely responsible.

The superintendent of a mine has enough to do with matters pertaining to coal movement without being obliged to attend to boiler operation. The solution of the problem would be to place such plants in charge of competent men, who would be held responsible for economical operation, and then back them up in their endeavors to produce desirable results.

The Engineer's Chair

One of our readers recently asked if an engineer's chair was a desirable adjunct to an engine room and questioned the advisability of reading while on duty. It appears that the management at his plant had ordered the chair and table to be removed and had denied the employees the privilege of reading while on duty. As he put it, eight hours was a long time to be on foot, and besides the order was a serious reflection on the faithful discharge of duty by the staff.

Our opinion would be that it all depends on the man, and his attitude toward his work. The efficient, uninterrupted and safe running of the plant are the first considerations. The man who is an engineer because he has a lively interest in his work and enjoys to the full "the inner compensation which goes with duties well done" is unlikely to abuse either the privilege of sitting down or of reading while on duty. If he does read it is something

which will help him directly in his work and not the latest cheap novels or copies of trashy periodicals. To keep up with the times and make himself more valuable to his employer, reading the current literature in his field is an absolute necessity, and whether he reads some or all of it at the plant depends upon the conditions, the efficiency of his co-workers and, as we have said before, upon his own character and disposition.

In some instances there may be a tendency to sit too long, and this will be apparent in the man who has no interest in the plant beyond keeping clear of a shutdown or in the man who grouches along day by day with one eye on the clock and the other on his pay check at the end of the month. Such an employee bears watching and should not be afforded facilities to make himself too comfortable. In any event he will not do any reading of the right kind, and ten chances to one will neglect his duties anyway.

He is not the man to be trusted in a plant in any capacity, and rather than to make a ruling concerning the utilization of his leisure moments, it would pay the company to replace him with a trustworthy employee.

Breakdown-Service Rates

According to *The Isolated Plant*, more than one hundred owners of private power plants have signed a petition to be presented to the Public Service Commission asking that body to fully investigate the existing rates of the New York Edison company for breakdown service, in case the company refuses to consider the question of arbitration. These owners have promised financial assistance for carrying on a suit, if necessary, in an attempt to obtain a just rate for such service.

Breakdown service is desirable as a safeguard against the possible failure of the isolated plant. It is conceded that a just rate for such service should be charged to cover the cost of installing the service, interest on the investment and for the protection the service affords.

At the present rate charged in New York City the users of breakdown service practically guarantee to use thirty dollars worth of electricity per year for each kilowatt of maximum demand. This means that if the owner of an isolated plant having a maximum capacity of two hundred kilowatts has a central-station connection to his switchboard as a precaution against shutdowns, he guarantees to pay for six thousand dollars worth of electrical energy during the year, no matter whether he uses it or not.

Naturally, the central station does not seek for nor favor this kind of service. It would prefer to put the isolated plant out of business. But it is a legitimate service for the consumer to demand, and the central station, in its capacity as a public utility ought to furnish it at a fair profit upon the cost of its rendition.

One of the excuses for the high rate demanded is that the central station must put in a kilowatt of extra capacity for each kilowatt of stand-by service which it takes on, must have extra boilers, generating units and help ready to furnish all of this current on an instant's demand. As a matter of fact they do no such thing. It is inconceivable that every isolated plant having stand-by service could break down at the same time, and at that time all be running at their maximum capacity. The electric company should not be allowed to charge overhead costs upon more than the actual reserve capacity held for stand-by service, and this apportioned upon the plants so served. It should be allowed a fair profit upon the service so tendered based upon its actual cost, and it should be compelled to furnish such service at a price which would yield such a profit, regardless of whether it wants to or not.

Signs of the Times

Continually increasing demands for high-grade power-plant equipment, capable of sustained high economy, have caused builders of it to make greater efforts than ever before to develop and perfect more economical apparatus.

Manufacturers of steam meters and feed-water meters, CO_2 recorders, recording-pressure gages, thermometers, pyrometers, etc., have met the demands of the progressive engineers, and new devices for indicating and recording operating data are being developed. Tube cleaners and scrapers, and feed-water compounds and treating apparatus are finding more extensive application. The practice of buying coal on the basis of the number of heat units it contains is spreading.

These are the external signs of the times. They point to changes in the practice of plant design and operation. Originally, almost the only aim was to keep the wheels turning. Now, however, with well perfected equipment available, more care is exercised in plant design, and low operating cost takes precedence over low first cost in the average case.

The Lazwell drainage-pumping plant, described in this issue, is a fair example of the improvements in design. As recent as ten years ago it would have been considered foolhardy to erect a plant of this character on a swamp for the sole purpose of pumping "ditch water." Almost any kind of machinery was usually considered good enough and the cheaper the better.

With improvements in design come greater skill and knowledge in operation. The raw materials, coal and water, are better understood and now it is not uncommon to analyze them systematically to the end that the one may be purchased and used more satisfactorily and the other may be suitably treated when needful to prevent waste through incrustation and corrosion.

The advantages of keeping close account of operating economy are fast being recognized and used: hence the increasing demand for instruments and gages to point to bad symptoms before too great inroads have been made in the coal pile.

Much progress has been made but much more still remains to be made. And a large part of this remainder is within the province of the operating man.

A metropolitan daily commenting editorially on New York City's smoke nuisance, says:

"The volume of the nuisance maintained by the Hall of Records is not so great as that charged against the New York Edison Co., but the smoke-stacks of the latter organization are greater."

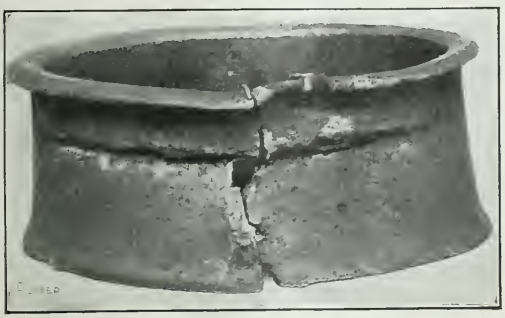
The conclusion reached is that the more stacks the more smoke, regardless of the amount and kind of coal burned, the way it is burned, and, in fact, whether or not any at all is burned! A smoke-stack simply *must* smoke.

READERS WITH SOMETHING TO SAY

Why Do Boiler Tubes Become Grooved?

The photograph shows the corroded end of a 4-in. tube taken from a horizontal tubular boiler. Five tubes in one boiler and two in another were taken from our boilers recently. The corroded tubes were all most seriously affected on top, the bottoms being but slightly corroded.

The groove in the tube end shown was so deep that it penetrated clear through in one place. The thickness



Corroded End of Boiler Tube

of the tube at the bottom of the groove is less than $^1/_{64}$ in.

It would be of interest to read discussions as to the cause of grooves forming in tubes. It will be understood that the thickness of the boiler head is ½ in., and that the grooves form close to the head on the inside of the boiler.

Sydney Whitaker.

Granville, Ill.

Why Not a Higher Vacuum?

We have an old-style engine running condensing and the most vacuum we can obtain is 10 in. The engine is of the double poppet-valve type, 16x42 in., making about 78 r.p.m., and taking steam about ⅝ of the stroke. The exhaust pipe is 8 in. in diameter and all packing around the rods seems to be in good condition and the exhaust line is tight. Recently we repacked all the tubes on both ends of the condenser.

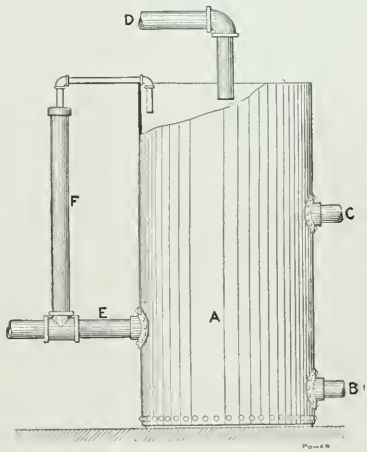
The condenser has 320 three-quarter-inch tubes, 8 ft. long, and has a partition running through the center. The intake is at the bottom and the outlet at the top. We have three 8-in. deep-well pumps delivering water to the condenser. The circulating water is about 58 deg. F. entering, and about 90 deg. leaving the condenser. Is the condenser too small? Could not the intake of the condenser be on top instead of on the bottom, and what difference would it make?

Rockport, Ind. William H. Shew.

Vent Pipe Prevents Water-Hammer in Heater

To stop the annoying water-hammer in a feed-water heater, I made changes in the piping as described below:

In the illustration *A* is a sheet-iron tank used as a hotwell, *B* is the feed-pump suction, *C* is the overflow to the sewer, *D* the makeup-water line, and *E* is the return main from a pair of dryers. Originally cold water was used as makeup water and the noise resulting from its use was intolerable. I changed the cold-water connection *D*, so as to feed hot water to the tank. This stopped the noise some, but not entirely, so I got after it again and put a 5-ft. length of 3-in. pipe *F* in the tee in the return main *E*, and reduced to 1¼ in. to vent it back into the



Vent in Heater to Prevent Water-Hammer

tank. There is very little noise now, as the steam that is in the return water can expand in the 3-in. riser and pass over to the tank.

R. Y. Bueger.

Somerville, N. J.

Piston Sticks and Breaks in Cylinder

While shutting our plant down for repairs this summer we had a 26x48-in. engine cylinder rebored and a new piston made for the same. The work was done by a local concern. When the new piston was placed in the cylinder, it lacked about $^1/_{64}$ in. of being a snug fit. The engine was started and run about five hours with a very light load. During this time we were using an inferior grade of cylinder oil which, we afterward found out, was sent by mistake. When the maximum load was reached and the governor had increased the cutoff from $^1/_8$ to about ⅜ of the stroke, there was a slight chattering-like motion of the connecting-rod. A few minutes later the

piston broke into 50 or more pieces without doing any further damage to the engine.

My opinion is that the piston broke, due to its expansion caused by not making proper allowance for the increasing temperature. Insufficient lubrication caused excessive friction between the piston and the wall of the cylinder, thereby raising the temperature above that due to the pressure of steam.

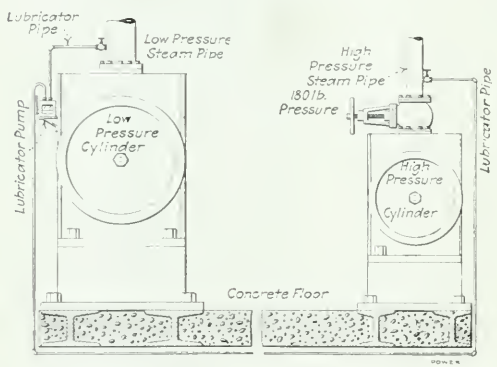
The piston stuck and stopped and the momentum of the flywheel forced the rod through the piston.

J. W. Dickson.

Memphis, Tenn.

Lubricator Improperly Located

While employed in a large railway power plant, we experienced considerable trouble with the lubrication of the high-pressure cylinder and valves of a 2000-hp. horizontal cross-compound Corliss engine. The oil pump was located on the outer side of the low-pressure cylinder, the latter being about 12 ft. distant from the high-pressure cylinder, as there was a large generator and flywheel on the engine shaft between the main bearings. This distance between the cylinders made it necessary to have 40 ft. of ¼-in. pipe from the oil pump to the high-pressure cylinder. The pipe led down the outer side of the low-pressure cylinder through the floor and across under it to the outer side of the high-pressure cylinder and up to an inlet in the steam pipe over the throttle valve on top of the high-pressure cylinder.



Oil-Pump Connections on Cross-Compound Engine

Most check valves leak more or less after being in service for a time, especially if under high pressure. As the pressure was 180 lb. in this case, it happened that after the engine was shut down for a number of hours, the pressure on the high-pressure lubricator inlet would force the oil through the leaky check valves and back through the pipe into the lubricator pump, condensed steam taking the place of the oil in the pipe. Then on starting, it would require possibly an hour's running of the engine at full speed to pump the oil back through the 40-ft. pipe. This unsatisfactory condition made it necessary to use the more or less wasteful hand-pump lubricator on the high-pressure cylinder at frequent intervals for an hour or more after starting the engine to get sufficient oil to the piston and valves.

The oil pump was transferred to the outer side of the high-pressure cylinder, thus reversing the arrangement and doing away with further trouble as there was no pressure on the low-pressure side to force the oil back toward the pump.

Edward W. McGregor.

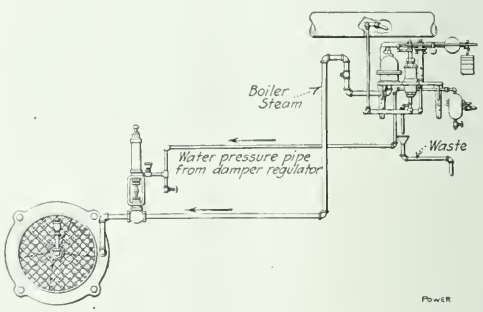
Panama Canal Zone.

Automatic Control for Draft Fan

The accompanying illustration shows an automatic arrangement I made to control the fan blower for a boiler plant.

Nearly all installations of engine-driven forced-draft outfits for boilers are automatically controlled by a damper regulator or diaphragm valve, and the arrangements of levers, valves, chains, pulleys, rods, etc., to accomplish this purpose are sometimes marvelously intricate and usually the more levers there are the more troublesome is the device.

My system appears to be free from the objections to which chains, pulleys, guides, etc., are heir. It consists of a diaphragm valve installed in the steam-supply pipe to the blower engine or steam-jet blower, the diaphragm chamber of which is connected by a ⅜-in. pipe to the chamber of the damper regulator on which comes the pressure to move the damper-regulator piston.



Fan Blower Controlled by a Damper Regulator

When the steam pressure rises to the point for which the regulator is set, water pressure is admitted to the damper piston, also through the ⅜-in. pipe connection to the diaphragm on the steam valve and closes it, thus shutting down the blower. In case the blower is run by an engine which must keep turning over to prevent stopping on the center, a bypass valve can be provided past the diaphragm valve and this bypass adjusted for the proper speed.

In practice this diaphragm valve can be provided with a weak spring so it will close before enough pressure accumulates to move the damper and also be the last thing to open.

Any number of similar valves can be operated by the one damper regulator and at any distance, around corners, etc., the only expense being the waste of the water the diaphragm holds at each operation; even this can be returned to the supply tank.

B. S. Remlieu.

Brooklyn, N. Y.

A Radical Cure for Hot Bearings

The main bearings of our cross-compound engine are 16 × 32 in. fitted with the usual babbitted top shell, and, besides the 50,000-lb. fly-wheel, they carried the armature of a 500-kw. generator.

This bearing, which was on the high-pressure engine, had given trouble from the start, and I was told when coming to the plant that this machine had never been run to speed (100 r.p.m.) longer than a few hours, and then the bearing ran very hot, necessitating the removal of the shells and cutting out of the oil grooves. I had the engine started, and, after running a short time, the generator was cut in on the line. In a few minutes smoke was seen coming from one of the handholes in the bearing cap before heat could be felt at either of the handholes in the cap.

The load was reduced, the machine taken off the line and the speed lowered to the point of turning over slowly. By this time the heat had come out on the end of the shaft, so the hand could not be held upon it.

Desiring to learn where the trouble started and not being a believer in the use of a top bearing shell, I prepared at once to do away with it by having the carpenters make a frame to place over the quarter bearings, the two side pieces of the frame being notched to receive the end pieces. While the carpenters were doing this I took off the shell and found the oil grooves well plugged. I cut open the grooves and scraped the bearings. Everything was then replaced except the top bearing shell. After this the engineer was able to run his hand the entire length of the journal and tell where the heating started.

The machine was again started and shortly after was heating just as much as before. I removed the cap and the quarter bearings, and using a flat chisel with faces ground to a long angle, and holding the chisel at a right angle to the journal, I cut along the entire length, turning up a "fin." I then smoothed the ragged edge with a file, my object being to use this fin to cut out the babbitt metal by turning the engine over. I did this with the quarter bearings out, after which I wiped away all the babbitt. I peened the fin down smooth, using a fine file for finishing the surface. The job proved to be a success from the start, and that was the best running bearing in the engine room.

P. A. Stafford.

Aransas Pass, Tex.

[With extreme care a skilled man might be successful with such a method. Severe cutting would result if chips from the shaft remained in the bearing.—Editor.]

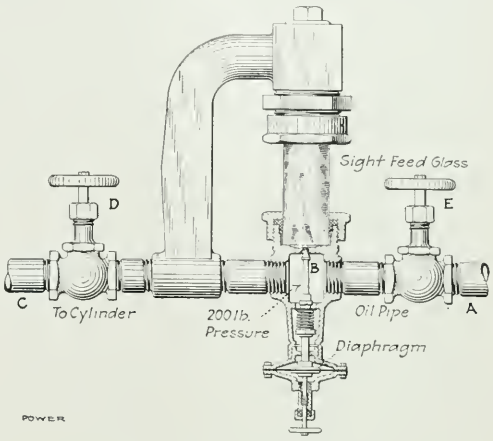
What Becomes of the Water?

The accompanying sketch is an illustration of our sight-feed oilers for lubricating the engine cylinders.

Referring to the diagram, the oil enters the pipe *A* under 200 lb. pressure, passes through the regulating needle valve *B*, through the sight-feed glass and out through *C* to the cylinder. *D* and *E* are globe stop valves. All but two oilers work perfectly. These are located on the high-pressure cylinder of a 1500-hp., tandem-compound engine. With these two oilers the water will disappear from the sight-feed glass almost every time the engine is shut down, the oil remaining and soiling the glass so that every morning I have to blow out the glass, and allow more steam to condense.

This has been getting rather monotonous, so lately I have had the night engineer close the valve *D* just before shutting down the engine, and so far have had no more trouble.

However, this does not explain where the water went to. These two oilers are connected to the steam chests



Lubricator That Gave Trouble

of the engine, all the rest are connected above the throttle so that they are subject to full boiler pressure at all times. The two causing the trouble are subject to boiler pressure while the engine is running and about 25 in. of vacuum after the steam has been shut off and the engine turned over a few revolutions.

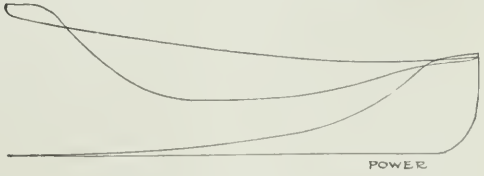
The only possible explanation I can give is that the sudden drop in pressure, when steam is shut off, causes the water to evaporate in the glass. The quantity lost, however, is over half the total in the glass, and it does not seem possible that the heat in the water will account for this much.

Thomas G. Thurston.

Chicago, Ill.

Indicator Diagrams for Comment

The accompanying indicator diagrams surely are unusual. They were given to me by an engineer at one of the plants in our town, and all the information that I can



Defective Indicator Diagrams

give is that they were taken from a Corliss engine with a 70-lb. spring, and the size of the cylinder is 18X36 in. The engine runs at 68 r.p.m. I would be pleased to have readers comment on the diagrams.

John T. Sharp, Jr.

Canton, Miss.

QUESTIONS BEFORE THE HOUSE

Advantages of the Steam Turbine

In the article, page 514, of the Apr. 8 issue, J. S. Leese, designates many of the turbine's good qualities, but he does not give the turbine all the credit it deserves. If he had handled large reciprocating sets and then turbines of corresponding or larger sizes he would fully appreciate other factors which he omitted. For instances, the stand-by losses are considerably less than with reciprocating sets; the turbine can be handled with less help, and can be brought from a cold state into service while warming a reciprocating set. The packing troubles are cut to a minimum and the only moving parts requiring attention are those connected with the oil pump and governor gear.

Then the consumption of oil is much less, and frequent adjusting of bearings is eliminated, unless there has been heating. The exhaust condensate can be returned direct to the boilers without traces of oil. Foundations are cut down to a minimum; in fact, a girder-constructed platform to allow the condenser to be placed underneath, with either lead or felt placed between the sole plate and girders, is all that is required.

A number of drains are done away with and there is less danger of damage being done if a slug of water happens to come over from the boilers. These favorable points added to those given by Mr. Leese only do the turbine's cause partial justice.

From my experience many turbine spindles are distorted from the effects of leaky valves while idle and too long a time taken in warming up with the machine stopped. The correct way to warm up is to get the machine turning over very slowly on the warming valve; if the warming valve is not large enough to start the rotor a puff of steam from the main stop valve can be applied, the machine then being kept turning over with steam from the warming valve. Particular notice should be taken that neither of these two valves are leaking, as the hot steam playing on the rotor in one position for a long period is likely to cause local distortion.

E. Russell Pearce.

Rochdale, England.

Volumes of Frustums

In the Mar. 11 issue of Power, page 355, is given a rule for finding the volume of a frustum of a pyramid or cone. It should be noted that this rule does not apply to frustums of wedges, and, therefore, the solution of the first problem directly under the rule is incorrect. The foundation described is a frustum of a wedge but not of a pyramid.

It may be further remarked that it is not often necessary to actually extract the square root in applying the rule as the numerical terms may usually be arranged so as to avoid this operation. In the second example, we find that

$$\sqrt{B \times b} = \sqrt{(300^2 \times 0.7854) \times (260^2 \times 0.7854)}$$

The expression under the radical can be grouped as follows:

$$300^2 \times 260^2 \times 0.7854^2$$

The square root of this expression is obtained by simply dropping the exponent 2 from each factor. Hence

$$\sqrt{B \times b} = 300 \times 260 \times 0.7854$$

The average man dislikes to extract the square root or to multiply large numbers. By following the plan suggested above the labor involved in the operation is minimized.

The prismoidal formula* can be used in obtaining the volume of frustums and has a wider application than the ordinary rule, but apparently is not so well known.

M. D. Gravatt.

Scranton, Penn.

Why Boiler Tubes Leak

Answering the inquiry by E. H. Hart, in the May 20 issue, I would advise that several reasons can be suggested as the cause of boiler tubes leaking at their ends.

Perhaps the fire-doors are left open over night to keep the steam pressure down, allowing a large quantity of air to circulate around the shell of the boiler, and it would perhaps hit the tube ends, causing them to leak. There may be defects in the brickwork around the back end of the boiler, and cold air may get through and strike the tube ends. The feed-water pipe may be installed in such a manner that cold water entering the boiler discharges against the tube ends. Mr. Hart does not say whether the tubes are corroded or just loosen and leak.

James E. Noble.

Toronto, Ont., Canada.

Replying to E. H. Hart, as to trouble with the outside tubes of boilers leaking at the ends. I would state that these tubes, being the more inaccessible, probably are heavily scaled. This would cause undue heating and leaking of the tubes at their ends. It is a difficult problem at times to get at the outside tubes.

John F. Hurst.

Louisville, Ky.

Pumping Air Exhaust of Mine Pump

On page 577 of the Apr. 22 issue is a letter by Mr. Houston on "Piping Mine-Pump Air Exhaust." He says the pump in question, which is a 12 and 6 by 13-in., works against a 400-ft. head. This would be equal to a pressure of about 173 lb. per sq.in.

The maximum air pressure is given as 90 lb. per sq.in., and, of course, would be still less at the exhaust end. Mr. Houston states that the pump is started by turning the exhaust to the atmosphere until discharge takes place through the regular discharge pipe, after which the ex-

*The use of this formula is explained in the Study Questions, June 4, 1912.

haust is turned into the latter. As there is a check valve on the exhaust pipe to prevent a flow of water to the air end of the pump, it looks as though air at 90-lb. pressure can be depended upon to open a valve against a water pressure of 173 lb.

The only way that I can see how such could be done is to get the exhaust into the discharge pipe before the static-head pressure of the water reached the given air pressure. Or, if the discharge pipe were full when the pump was to be started, it could be drained off to the required head.

Of course, when the pump is once in operation as described, the head pressure will not be that due to 400 ft., as the action of the air would tend to be the same as in an air-lift system. This would mean that there would be alternate layers of water and air all the way up in the discharge pipe.

This would bring about a condition that Mr. Houston should experiment with regarding the effect on the capacity of the pump. A given flow of water and air mixed would mean a lesser pump capacity than if the pipe contained only water. But as the pressure would be reduced owing to the presence of the air, the velocity of flow would be increased with a given pump speed.

J. A. CARRUTHERS.

Hosmer, B. C., Canada.

Regarding the method of piping the exhaust and discharge from a mine pump explained by Mr. Houston, in POWER of Apr. 22, 1913, I felt at first with Mr. Bridges (POWER, May 27, 1913, p. 755) that I had one on the editor. However, before I got through I had thoroughly satisfied myself that Mr. Houston was correct.

The point seems to be that after making the new connections the pump does not begin to work against the 400-ft. head, but instead the pipe from the pump to the surface is empty. As the water begins to rise in the pipe, the air from the pump begins to exhaust into the pipe too, thereby lessening the average specific gravity of the column contents against which the air must exhaust. The air discharged by each stroke of the pump would be eight times the volume of water discharged if it expanded only to an average of 37½ lb. gage pressure. If all eight volumes of the air remained in the pipe there would be room for only 45 ft. of water column, equivalent to only about 20 lb. gage, which would allow for a still greater expansion of the air. As a matter of fact, equilibrium would be reached by a certain amount of air rushing up past the water, but theory seems to point to a big leeway for this process. Even after the pump was originally started with the new connections, and then shut down, the pipe would not remain full enough of water to prevent again starting the pump, added to which, it is always possible to bleed the line before restarting. If the pump had to be started with the 90-lb. air exhaust piped in against a 400-ft. water column, Mr. Bridges is right, there would be "nothing doing," but it does not work that way.

DONALD M. LIDDELL.

Elizabeth, N. J.

Comments on Flue-Gas Readings

The statement made by F. A. Lowe under the title, "Flue-Gas Readings for Criticism," in POWER of May 20, 1913: "It will be noticed that a minus sign is put before some of the CO readings. This sign indicates that the CO reads less than the O" seems to need some explanation. All of the CO readings are less than the O readings. If the statement should mean that the CO reads less than zero, it is probably to be explained by the use of an old cuprous-chloride solution, which gave up some of its CO to the gas being tested.

DONALD M. LIDDELL.

Elizabeth, N. J.

Best Form of Link

Referring to the problem of S. N. Bowman, page 642, May 6 issue, as the bending stresses in the links would depend on their own weight they should be of I-beam section, so as to combine the greatest stiffness with the least area of cross-section. The dimensions of their cross-section would depend on the permissible vertical motion of the suspended weight after its impact, as upon impact there would be a shortening of the distance between the suspending pins, due to deflection of the links, and the amount of that deflection would depend upon the specific weight and bending resistance of the material employed for the links.

A. T. KASLEY.

Swissvale, Penn.

Referring to the problem submitted by S. N. Bowman, in the May 6 issue, it is a law of mechanics that when a body descends from one horizontal plane to another, without friction, then when it has reached the lower plane its velocity will be the same as if the body fell freely from the one plane to the other, no matter what path is followed. This means that the weight at the instant the blow is struck will have the same velocity that it would have by falling 10 ft. from a position of rest. Therefore, the velocity at impact will be

$$v = \sqrt{2gh} = 8.02\sqrt{10} = 25.34 \text{ ft. per sec.}$$

The centrifugal force of a body revolving about a point is

$$F = \frac{mv^2}{R}$$

where

m = Mass = $\frac{\text{weight}}{32.16}$;

v = Velocity in feet per second;

R = Radius in feet.

Hence the centrifugal force of the descending weight is

$$F = \frac{\frac{15{,}000}{32.16} \times 25.34^2}{18} = 16{,}640 \text{ lb.}$$

To this must be added the weight of 15,000 lb., making a total tensional stress of 31,640 lb. on the four rods or links, which is

$$31{,}640 \div 4 = 7910 \text{ lb. per link}$$

Owing to the jar at the instant the blow is struck the factor of safety should be high and on this point engineers would probably differ somewhat. However, if the links were of wrought iron, a load of 5000 lb. per sq.in. would certainly be within the limit of safety, which gives

$$\frac{7910}{5000} = 1.58 \text{ sq.in. or say } 1.6 \text{ sq.in.}$$

as the minimum area of cross-section of each rod. Taking

the weight of 1 cu.in. of wrought iron as 0.28 lb. and allowing 2 ft. on each link for the eye, the four rods will weigh about 450 lb., which does not add enough to the load supported to make a second calculation of area necessary. Hence, wrought-iron links having a cross-section of 1.6 sq.in. each will be strong enough as far as tensional stresses are concerned.

When the weight strikes, the centrifugal force ceases at once, therefore, any other stress that might occur will arise from the effect of stopping the motion suddenly. As the weight hits squarely and horizontally no vertical stresses will be set up, which leaves only the motion of the links to be considered. The kinetic energy of a moving body is found by multiplying the weight by the square of the velocity of its center of gravity and dividing the result by 64.32. The velocity of the center of the rod is one-half that of the lower end; hence

$$\textit{Kinetic energy of the four links} = \frac{450 \times 12.67^2}{64.32}$$

$$= 1123 \textit{ ft.-lb.}$$

This energy is given up while the weight is moving 2 in., or as the center of the links is moving 1 in. $= \frac{1}{12}$ ft. Now bearing in mind that the retarding force multiplied by the distance through which it acts equals the kinetic energy of the rods,

$$F \times \tfrac{1}{12} = 1123$$

or

$$F = 13{,}476 \text{ lb.}$$

that is, the inertia of the rods at the time of impact, causes a force of

$$13{,}476 \div 4 = 3369 \textit{ lb.}$$

per rod, provided the center of the rod comes to rest after moving 1 in. As a matter of fact, however, the links will vibrate or spring much more than this and it would not be unreasonable to expect an 18-ft. rod a little more than 1 in. in diameter, to spring 2 in. or even more at the instant of impact, so that the actual horizontal force from this cause would probably be less than 1000 lb. per rod. With the low terminal stress allowed, a link of round cross-section and of cross-sectional area to safely take care of the stress of tension will be amply strong enough to provide for any other stresses that will occur in this case. If the links are made of flat iron, they should be made so that the flat side is perpendicular to the plane of motion. Otherwise, severe stresses may be set up at the instant of impact.

An intricate theoretical discussion may be woven about this problem, but I have considered it as a practical example and have used a practical method of solving it. Slightly different results, no doubt, can be obtained by other methods, but the results here are close enough for all purposes.

W. G. Hawley.

Scranton, Penn.

Valve Setting

Mr. Walchli's theory (page 614, Apr. 29 issue) that the engine should be turned opposite to the action of the connecting-rod to locate points *A*, *B* and *C* in his sketch is correct for putting the engine on center, as lost motion in the crankpin and the crosshead pin should be taken up on each side of the center by rotating the wheel so as to strain the connecting-rod in the same direction as when the engine is running.

The statement of the "Power Handbook" refers to the way of putting the engine on the center to adjust the valve. The booklet is correct in stating that lost motion of the eccentric, valve rod, etc., should be taken up by turning the wheel in the same direction as when the engine is running. With *C* properly located it makes no difference whether lost motion is greater in one place than another, as, in locating the point *C*, the valve is not being adjusted, and when setting the valve, *C* is already located and the connecting-rod could then be disconnected.

However, any engine needs keying up if it has enough lost motion in either place to make any noticeable difference which method is used.

Harry D. Everett.

Fort Apache, Ariz.

Preventing Cylinder Condensation

The article on page 705 of Power, May 20, relative to cylinder condensation and the remark contained therein as to it being common for engineers to run engines with the drip valves open, or partially so, leads me to suggest a remedy I have employed successfully to overcome this practice.

The plan consists simply of the installation of automatic cylinder cocks. I have obtained excellent satisfaction by the use of these cocks on slow- and moderate-speed slide-valve engines, especially on low-pressure cylinders exhausting into a vacuum in which case the outlet or drain from the cock should be connected to the exhaust pipe between the condenser and exhaust valve.

These cocks also work well on noncondensing slide-valve engines as, being connected to the lowest point, they permit the accumulated condensation of each stroke to be blown out of the cylinder without the loss of any steam.

The drainage pocket illustrated in the article referred to would require special and peculiar design for use on any cylinder having four rotary or Corliss valves. In this style of cylinder it would appear that the exhaust port in the cylinder, being in the bottom at each end, should form practically just such a pocket or well having a cubical capacity the clear length, width and the depth of exhaust port from cylinder counterbore, into which the exhaust port opens to the top of the exhaust valve.

W. Oliver.

Racine, Wis.

Losses Due to Compressor Piping

The story with the title quoted above, as told by A. D. Palmer, on page 611, in the issue of Apr. 29, is somewhat puzzling. With an insufficient supply of steam at too low a pressure the compressor ran at 200 r.p.m., while with plenty of steam at a higher pressure it ran at only 125 r.p.m. At the higher speed the air pressure maintained was 20 to 40 lb., while at the lower speed the pressure was 50 to 70 lb. In both these particulars the results reported are exactly the reverse of what should have been expected, and it would seem that some additional explanation would be in order.

Frank Richards.

New York City.

INQUIRIES OF GENERAL INTEREST

Foot Valve—What is a foot valve.

P. M.

A foot valve is a check valve such as is usually placed at the lower end of a pump suction pipe to prevent the water in the pipe from running down when the suction is not in action as between strokes, or starts and stops.

Oil in Gas Collector—On the surface of the water in a collector for flue-gas analysis samples, oil is used. What is it for and what kind should be used?

J. W. D.

The oil forms a seal and prevents the water from absorbing any of the elements of the gas sample. An ordinary machine oil may be used. How to use it is told in a letter by Robert H. Schafer, "Another Serviceable Gas Collector," in the Dec. 17, 1912, issue of "Power," page 910.

Suddenly Opened Valve Effect—What effect would it have on the water line of a boiler to suddenly open a stop valve or safety valve?

P. C.

If the valve is opened suddenly while the boiler is under pressure, the water line of the boiler would rise, for steam would be suddenly liberated in the body of the water of the boiler and in ascending to the steam space, the steam would tend to lift the whole body of the water.

Steam Generation Temperature—At what temperature will steam begin to be generated in a boiler filled to the running level with water at 35 deg. F. and the steam space filled with air at 100 lb. pressure?

L. C. S.

So far as the temperature at which steam will begin to be formed is concerned these conditions are no different than if the boiler were in regular operation at 100 lb. steam pressure. The temperature will, therefore, be that found in steam tables corresponding to a pressure of 100 lb. gage or 338.1 F. In this case the water will have to be raised through a temperature range of

$$338.1 - 35 = 303.1 \text{ deg.}$$

Number of Staybolts Required—If the area of the segment of the head of a tubular boiler above the tubes is 714 sq.in., and the steam pressure is 100 lb. gage, how many 1⅛-in. braces would be required of a working strength of 7500 lb. per sq.in. of cross-section?

F. M.

The total pressure to be resisted is

$$714 \times 100 = 71{,}400 \text{ lb.}$$

A 1⅛-in. diameter stay would have a cross-sectional area of 0.994 sq.in. Then its allowable strain is

$$7500 \times 0.994 = 7455 \text{ lb.}$$

and the number of stays required is

$$\frac{71{,}400}{7455} = 9.57$$

or the next largest whole number, ten.

Removing Boiler Tubes—What is the proper way to remove tubes from a vertical tubular boiler and what is the best way to put in new tubes?

L. M. N.

The common way to remove tubes is to cut the ends with a cape chisel. One end of the tube is slit through and is then collapsed enough to drive it into the boiler so that the tube may be removed through the tube sheet on the opposite end of the boiler. Care must be taken not to injure the sides or edges of the tube holes, otherwise it will be difficult to make the new tubes tight. To remove tubes from an upright boiler without throwing it over on its side, the tubes are detached from the furnace-tube sheet, and sufficiently loosened in the upper flue sheet to withdraw the tubes through the top. New tubes have to be expanded into the tube sheets, preferably using a roller expander. Beading is done with a thumbing tool, which must be handled with care to avoid splitting the tube ends, especially if the tubes are not of the best quality.

Engine Pound—There is a clattering noise in our engine cylinder occurring at the ends of the strokes. Is this due to condensation, and if so, how can it be remedied? It is a Corliss engine and has no cylinder cocks.

J. P. M.

As shown by the diagrams sent with the inquiry, steam is expanded down to and probably at times below exhaust pressure. The noise is, therefore, likely due to the exhaust valves being subjected to pressure on the reverse side at the end of each stroke. Lowering the initial pressure would stop the trouble, and, if it is not convenient or desirable to decrease the boiler pressure, the admission may be throttled, which would have the additional advantage of insuring dry steam, so that if there were trouble from condensation it should be removed also. Another remedy is to crack the indicator cock so as to prevent the pressure in the cylinder from becoming less than that in the exhaust pipe. This would be advisable only if the initial pressure cannot be reduced enough to prevent expanding to such a low terminal pressure.

Increased Boiler Horsepower—If a boiler 5 ft. 3 in. long containing 134 tubes, 2¼ in. in diameter, is retubed with 2½-in. tubes, how much is the horsepower increased?

P. C.

A 2¼-in. tube has a circumference of

$$2\tfrac{1}{4} \times 3.1416 = 7.068 \text{ in.,}$$

and a 2½-in. tube,

$$2\tfrac{1}{2} \times 3.1416 = 7.854 \text{ in.}$$

The 2½-in. tube is, therefore,

$$7.854 - 7.068 = 0.786 \text{ in.}$$

greater in circumference and the length of the tube being 5 ft. 3 in., or 66 in. the increase of area, using 134 tubes is

$$\frac{0.786 \times 66 \times 134}{144} = 48.27 \text{ sq.ft.}$$

Allowing, according to modern commercial rating of tubular boilers, a boiler horsepower to each 10 sq.ft. of heating surface and the new tubes would increase the horsepower

$$\frac{48.27}{10} = 4.827 \text{ hp.}$$

Or, by the old rating of 15 sq.ft. per hp.,

$$\frac{48.27}{15} = 3.22 \text{ hp.}$$

Variation of Boiler Efficiency with Load—What are the comparative efficiencies of a boiler at different percentages of rated capacity? What is the greatest capacity at which it would be desirable to operate a boiler continuously?

S. C. A.

Under ordinary good conditions of operation and good proportions, with clean boilers, the highest efficiency is usually obtained when forced to about 50 per cent. excess of normal capacity. At one-quarter capacity boilers will generally yield about three-fourths the efficiency of 50 per cent. estimated capacity and their efficiency gradually increases up to 150-per cent. capacity. At 200 per cent. a boiler will usually give a higher efficiency for a short time, or until the flues become dirty, requiring extraordinary cleaning. It is never advisable to overload a boiler more than 50 per cent. as the grates, furnace linings, walls and many parts are likely to be damaged when used at furnace temperatures exceeding those for which they were designed.

If the boiler has been set with the size of grate, kind of setting, etc., appropriate for a given capacity, it would not be desirable to operate it at any higher capacity continuously even though higher efficiency might be obtained, as the parts are likely to be injured and any advantage gained would be likely to be more than offset by the greater care and attention for cleaning, repairing, safety, etc., that would be entailed.

Errata: Vacuum at High Altitudes—In the answer to the inquiry under the above title in the June 10 issue, the mistake was made of subtracting 0.03 lb. from 9.8 lb. instead of adding it. The pressure should have been 9.83 lb. per sq.in., which would balance

$$9.83 \times 2.0355 = 20.009 \text{ in.}$$

of mercury instead of as given before 19.887 in. The error is not serious in amount nor does it affect the final statement

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis

Following are the solutions of the problems in the last lesson. Applying the formula given in the same lesson as the problems we have

$$C \times 14{,}600 + \left(H - \frac{O}{8}\right) 62{,}000 = 0.6365 \times 14{,}600$$

$$+ \left(0.0526 - \frac{0.1012}{8}\right) 62{,}000 = 11{,}773 \; B.t.u. \; per \; lb.$$

In the second problem the sum of the percentages of volatile matter and fixed carbon is

$$35.51 + 50.06 = 85.57$$

and dividing this into the percentage of fixed carbon and multiplying the quotient by 100 gives

$$\frac{50.06}{85.57} \times 100 = 58.5$$

the percentage of fixed carbon in the combustible. After locating the 58.5 point at the bottom of Fig. 2, in the last lesson, tracing an imaginary line straight up to the curve and then horizontally across to the left margin, we find that the heat value per pound of combustible matter is 14,975 B.t.u. Then, as but 85.57 per cent. of the coal in the problem is combustible matter, the heat value per pound of coal is

$$14{,}975 \times 85.57 \div 100 = 12{,}814 \; B.t.u.$$

Value of Flue-Gas Analysis

Thus far we have been studying fundamental principles only and, no doubt, many have wondered what was the use of lumbering up their brains with such matter if it could not be put to some practical use in plant operation. Beginning with the present article we will take up the application of these principles and after we have mastered a few more, we will be able to apply all of them to good advantage in securing greater efficiency in boiler operation

Let us assume that we have succeeded in discovering the best coal, all things considered, for our plant. By making proximate analyses and estimating heat values we have found one grade of coal which has minimum moisture and ash; consequently, it gives maximum heat-generating material per dollar invested. Upon actual trial in the boiler room it is found to work satisfactorily with the existing equipment. It does not clinker badly and, hence, the firemen can handle it easily and efficiently and maintain the steam pressure uniform without undue trouble.

Our next problem is: How best to burn this coal so as to get most of the heat it contains into the boiler and generate the greatest quantity of steam possible per pound of coal fired. And right here is where our knowledge of the underlying principle of combustion comes into use.

Excess Air Necessary

In preceding lectures it was shown that each pound of coal of a certain composition requires a certain fixed weight of air for complete combustion and the method of figuring this weight was given. But, this theoretically required amount of air will not suffice in the boiler plant because if only the required amount is supplied, the distribution must be perfect so that each particle of oxygen in the air may come in contact with a particle of carbon or hydrogen. If this does not take place, some of the oxygen will escape without combining with its allotted share of the combustible matter, with the result that either of the two following things may happen: Some of the hydrogen may escape unburned, or some of the carbon may be only partly burned and form CO instead of CO_2.

In the boiler plant this perfect distribution of the oxygen is impossible. Consequently, an excess quantity of air must be supplied to the fuel in the furnace in order that complete combustion of every particle of the burnable matter may be effected and no loss suffered from combustible gases escaping up the chimney.

Importance of Knowing Required Excess

Now, too much excess air is equally or even more detrimental to good economy than too little. Assume a given coal requires 10 lb. of air per lb. of coal for complete combustion and that the gases formed weigh 10.75 lb. The heat value of a pound of this coal is, say, 10,000 B.t.u. Immediately after combustion all this heat is contained in the 10.75 lb. of gases and due to this fact their temperature is very high. We are not ready just yet to estimate how high, so let us assume the temperature to be 3500 deg. F. As these intensely hot gases come in contact with the heating surface of the boiler and give up their heat to the water within, their temperature falls until it reaches, say, 500 deg. as the gases leave the boiler. The gases are still much hotter than was the air and coal which went to make them up and as they obtained their heat from the coal, all the coal's heat did not go into the boiler to make steam, but some was lost up the chimney.

Now, if 20.75 lb. of air were fed per pound of coal, instead of only the required 10 lb., double the quantity of gases would pass from the boiler. And as these gases would escape up the chimney at about the same temperature as the 10.75 lb., the heat loss would be about double that in the first case. This is true because with equal temperature the heat contained in 21.50 lb. of gas is just double the amount contained in 10.75 lb.

Thus, it is important to discover just what amount of excess air is most economical under the existing conditions in your plant and in order to know this some means must be employed to measure or calculate the air supply to the boiler.

Estimating Air Supplied

Direct measurement would be difficult to make and unsatisfactory in accuracy. A far easier and more accurate means is to analyze the flue gases and calculate the air supply from this analysis and the coal analysis. Flue-gas analysis is also useful in checking boiler opera-

tion from day to day so as to be sure conditions will remain economical.

Simplicity of Flue-Gas Analysis

Somehow or other, flue-gas analysis has a very mysterious and forbidding sound. People are inclined to think it is too deep and dark for them to understand and, consequently, many have not made the good use of it that they should. As a matter of actual fact, it is simple to understand and easy to master. The trouble has been, however, that apparently no one has taken the trouble to explain the case fully and thoroughly. This is just what POWER now aims to do. And right here perhaps is a good place to remind you that if what we print in this department is not perfectly clear to you or if you cannot succeed without further assistance, do not hesitate to write for help or advice. You letter will be welcome; it will be turned over to the writer of these lectures and treated confidentially.

Apparatus Required

A suitable apparatus is required for making a flue-gas analysis. Numerous types are on the market all of which have points of merit. Most of them, however, are based on the Orsat apparatus which was designed by a man of that name and which has been so extensively used that the name has come to be almost as typical as such names as Corliss, Babbitt, etc. For this reason, the principle and operation of the Orsat only will be given here.

Following is a list of the essentials of a flue-gas analyzing outfit:

1 standard Orsat-Muencke flue-gas analysis apparatus	$20 00
2 rubber gas bags for pipettes @ 50c. each	1 00
2 large glass bottles, @ 50c. each	1 00
2 rubber corks for bottles @ 15c. each	0 30
10 ft. antimony rubber tubing (¼ in.) @ 10c.	1 00
10 ft. of ¼-in. glass tubing in 5-ft. lengths @ 2c.	0 20
4 Mohr's pinch cocks @ 8c. each	0 32
1 German-glass funnel (2-in. size)	0 10
1 lb. caustic potash (purified sticks)	0 35
¼ lb. pyrogallic acid	0 80
1 lb. commercial copper oxide	0 55
1 lb. muriatic acid	0 30
10 ft. copper wire No. 10 gage @ 10c	1 00
Total	$26 92

There are several different makes of Orsat apparatus, such as Orsat-Muencke, Orsat-Lunge, Orsat-Fischer, etc. But all are based on exactly the same principle and differ only in regard to minor details of construction. For instance, the Orsat-Fischer has four pipettes instead of three. Just what a pipette is will be clear presently.

⁂

All predictions of past years that coal could not be worked at a greater depth than 1500 ft. no longer hold water. At the present day, according to W. E. Garforth, president of the British Institute of Mining Engineers, coal is being mined at depths exceeding 3000 ft. The adoption of a system of long-wall working has solved the question of superincumbent weight. The coal is exposed to this weight for a very short time and places are closed up rapidly.

⁂

For the increase of the Birmingham, England, municipal electric supply, it is proposed to erect a new power station at Nechells, with an ultimate capacity of 100,000 kw., of which 10,000 are to be available for the winter 1915-16. Marine type water-tube boilers, fitted with superheaters and overhead economizers are to be erected. Ashes are to be removed from the boilers by a new system operated by air suction. The cost of the first installment of the station, including the extensions required in substation equipment for the next five years is estimated at $2,316,000. The Summer Lane station (25,500 kw.) is also to be increased to 36,500 kw. capacity next year. The stations at Water St. and Aston have 3040 and 4550 kw. capacity, respectively.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Right up to now, we believed that "imitation is the sincerest flattery." Now we're skeptical—having seen the calendar of the Viscosity Oil Co. It's well named, and literally; Anything viscous is ropy and glutinous, which may be the reason it roped our "What the Diagrams Tell," published in 1910, and glut(t)inously adhered to it in every detail but one—it did not photograph the word "Power" along with the rest of the chart. If the Viscosity Oil Co. has an explanation to offer, all well and good. If not, we'll take it for granted that it's willing to stand by its apparent ignorance of the meaning of the word "etnics." We say ethics because it sounds so real polite; it could be made stronger.

⁂

Our much esteemed contemporary, "Factory," is as meaty, juicy and appetizing as a porterhouse steak. But——. If we have earned our right to be critical, we ask where in Tophet did that cubist artist get the idea on the front cover that a tornado of smoke typifies a busy factory? The more fire the less smoke is Hoyle today.

⁂

Nothing is more unconsciously hypocritical, remarks Dr. Talbot, than "We have done a great deal for our employees." The good doctor says it should read: "We have done a great deal to make conditions favorable for profitable work." The lay public has been so completely carnegied into the belief that every man who spends a dollar on bettering his plant or shop is a philanthropist, that it is refreshing to have the actual truth. Hooray for the doctor!

⁂

WHAT'S IN A NAME?

By Billy B. Damm

In a manner of speaking, the Bard of Avon called the turn in "Othello," when he remarked, "He that filches from me my good name robs me of that which not enriches him and makes me poor indeed." But it must be a good name, and opinion differs as to what constitutes a good name. Now, there's Orlando Dammit, of Elmsford, N. C. He wants the state solons to change his. The jokesmiths, wanting to heckle Orlando, ask why.

I ask Dammit, why NOT? Dammit, why not? I'd change it. Let's see: O. Dammit—Orlando D. Mit—O. Mit— I can't get it, Dammit. But cheer up, Dammit. Dammit, cheer up! Say, Orlando, supposing you— It's no use, Dammit; see the legislature, but steer clear of those lobbyists Blankitt and Dashitt.

Your not alone, Dammit, in your difficulty. We once knew a grocer—nice fellow, but a little light weight—whose sign read:

"A. SCHWINDLER"

He really wasn't, but folks kept saying so. It was suggested that he get a new sign and spell out his Christian name, the first in ancient history. The new sign he nailed up read:

"ADAM SCHWINDLER"

You certainly haven't forgotten the Dam family, Giv. A. Dam, fat Willie Dam, Lena Dam and Godfrey Dam? Think of this crowd going to hear Wagner's opera of "Goetterdaemmerung"!

Gretchen Schwein, in my home town, up and married Milton Hogg, and the envious began to wonder how she could have made a Hogg of herself.

Helga Johansen went to school with me—a real nice, jolly girl, and we called her Helga. Some of us fondly called her Hel—just like Liz, for Lizzie, and Gwen for Gwendolyn. We'd see a girl down the street starting off for school, and Tommy Rott would say: "Billy, that looks like Hel!" Well, she did and she didn't. Many of the fellows would go to Hel with their troubles, she was that sympathetic. She afterward married a chap named Biers, who drank himself to death.

There's lots in a name, depending on the point of view. I knew a man who gave his to seven different ladies. When he had done his six years he told me that he had made up his mind to settle down—he'd already settled up with the irate seven—and get married.

Traugut Walsingham's mother named him after her grandfather, so that the boys couldn't nickname him. They called him "Gutsy" his first day on the street.

What's in a name? You can search me, as Blink Boffum said when asked where all the bugs went in wintertime.

Steam-Boiler Efficiencies

By A. Bement*

SYNOPSIS—Answer to William Kent's criticisms of the experiments on transmission of heat into steam boilers made by Henry Kreisinger and Walter Ray for the Bureau of Mines.

Under the above title, William Kent, in the October issue of the *Engineering Digest,* severely criticizes experiments described in the Bureau of Mines Bulletin No. 18, entitled "The Transmission of Heat into Steam Boilers," by Henry T. Kreisinger and Walter T. Ray. In addition, he charges the bureau with wasting money and effort in executing this work. The research was a worthy one. Its execution was in the hands of those who originated it. The research had the unqualified endorsement of Prof. L. P. Breckenridge, who had charge of the steaming tests, and his influence was an important factor in advancing the experiments.

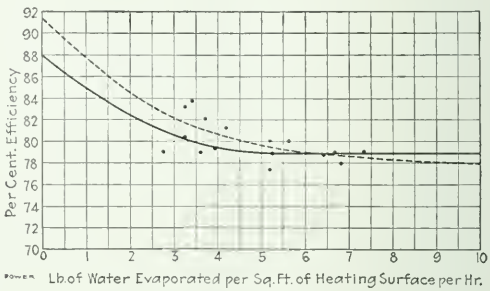
Mr. Kent quotes from an earlier Bulletin, No. 325, page 178, as follows: "The authors see no reason why boilers cannot be constructed and probably operated with entire satisfaction, which will produce about ten times the amount of steam now obtained per square foot of heating surface and with no difficulty in obtaining dry steam." And he says that five years later, in Bulletin 18, the authors do not repeat this "extragavant" statement, but are content with the milder one that "the present steaming capacity can be tripled and quadrupled by forcing over the heating surface three or four times the weight of gases now passed over them."

The writer's understanding is that, when the authors made the first statement, they had in mind the belief then held by many people that boiler capacity is limited by the capacity of the metal-heating surface to convey heat from the receiving to the delivery side of the plate. What they probably meant was that the heat transmitting capacity of the plate or tube is at least ten times the capacity usually expected of it; there is no evidence that this statement is not true. Before the bulletin containing the statement was published, Mr. Ray made for me an estimate of the power necessary to force sufficient gases through a boiler to insure the large capacities in question and his figures showed that, long before a capacity ten times greater than usually obtained was secured, the entire steam production of the boiler would be required to furnish power for the draft, even with the most efficient fans.

Most of their experiments were made with a very small boiler, a piece of laboratory apparatus. The heat was furnished by wire coils electrically heated. Air passing over these coils carried heat to the boiler surface. This arrangement enabled an exact regulation and avoided the dangers of incomplete combustion incident to any form of fire. Thus it eliminated the troublesome variables which cause confusion and lead to erroneous conclusions in experiments with large boilers heated by combustion. Hence the small boiler was justified, notwithstanding Mr. Kent's argument that a large boiler should have been employed.

The authors make prominent what they call "true boiler efficiency," which allows for the contents of a boiler being hotter than the atmosphere, for which reason less heat will flow into it than if it were at atmospheric temperature. All heat in the gases below the steam temperature would not be available to the boiler and is not charged to it in the true boiler efficiency. Whether this particular expression is justified and some other would have been better, may be questioned, but not the fact above stated, yet Mr. Kent presents several examples in an effort to disprove it. Apparently he considers this "true efficiency" analogous to constant efficiency, because his calculations which give a discordant result instead of a constant one, embody several variable conditions, such as initial temperature, capacity and steam temperature.

Mr. Kent states that "a steam boiler has no efficiency which depends only on the structure." This seems to be his principal disagreement with those adopting newer



Variation of Boiler Efficiency with Capacity

views on steam-generator performance. Evidently he holds to the old theory that has denied individuality to the boiler, and insisted that instead of its being a definite part in steam-generating apparatus, a "boiler" includes boiler proper, fire bars or stoker, brick walls, fire, chimney, etc. He states that it can have no efficiency which is not dependent on its operation, meaning that of the combined apparatus plus condition of combustion, which includes all the possible variables, as imperfect combustion, fuel lost in ashes, excess of air, etc.

When such an eminent authority as Mr. Kent states that a boiler can have no efficiency based on its structure, argument to the contrary calls for positive proof. In the latter part of Bulletin 18 are some examples of large boiler performance corroborating experience with the small boilers. One is that of boilers in the plants of the Commonwealth Edison Co., in Chicago. These were of the box-header water-tube type, having no baffles nor division plates within the tube surface.

The hot gases entered at the bottom of the tube surface in the rear and left at the top in front. One boiler had two horizontal baffles inserted, as shown at page 157 of Bulletin 18, which caused the gases to flow in a much more restricted channel than before, and to traverse a distance of 36 ft. in contact with the tube surface, instead of 13 ft. in the unbaffled boiler. The two boilers were in the same battery and otherwise identical. There-

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fore any difference in their performance must be due to the difference in baffling.

In the tests, the baffled boiler had one-third less draft in its furnace than the other, due to the resistance of the baffling, yet it evaporated 5 per cent. more water, and with only two-thirds as much of the same coal. One of these boilers absorbed more of the heat flowing through it than the other, and did so because of its structure, for the fire, as shown by gas analysis, was the same for each boiler.

The basic claim of Messrs. Ray and Kreisinger is that the velocity of the gases has an important influence on the flow of heat into the boiler. In this connection Mr. Kent quotes from Bulletin 18 the statement that "the efficiency of a boiler as a heat absorber can be increased by arranging the heating surfaces in such a way that the gas passages are long and of small cross-section," which he says, "is merely a deduction from unproved hypothesis." Nevertheless, this is just what was done with the Commonwealth boilers. That Mr. Kent makes no reference whatever to the work of Prof. John T. Nicolson, the tests of the Interborough Rapid Transit Co. and Commonwealth Edison Co., which are all with "actual boilers," is strange, considering a review of Bulletin 18, in which these appear, could not properly ignore these experiments.

That the velocity of the gases has an effect is apparent without the evidence of such tests. An object at lower temperature will be heated faster by a flowing current of hot air than by air without motion, just as a person gets colder if the wind blows than if it is still, the temperature being the same.

Three Principal Elements

As I look at the matter, the efficiency of a boiler is based on three principal elements as follows:

1. Form of gas passages, causing the hot gases to come in contact with more or less heating surface.
2. Time in which the heated gases are in contact with the heating surface.
3. Velocity of the hot gases in their flow through, or in contact with the heating surface.

Upon this basis the operation of the triple-flow boiler of the Commonwealth Edison Co., may be defined as compared with the single-flow boiler as follows:

A. The multiplicity of passages carried the gases into contact with more heating surface.

B. The contracted areas necessarily increased the velocity.

C. The length of travel of gases being greater than the increased velocity, they were consequently among the heating surfaces a longer time.

As I understand the conclusions of the authors of Bulletin 18, they consider that when capacity has passed a certain point, efficiency becomes constant. Before that point is reached, however, it decreases as capacity increases. Thus efficiency would drop as capacity increases until this point is reached, after which it would become constant. Mr. Ray informs me that with the single-pass Heine boilers used at the St. Louis Exposition, the point of constant efficiency began at an evaporation of 6.9 lb. of water per square foot of heating surface per hour. When the same boiler had been double-passed by the insertion of one baffle, efficiency became constant at an evaporation of 4.3 lb. of water per square foot. Also that with an average 2-in. locomotive boiler tube, constant efficiency is reached at a capacity of 3.5 lb. evaporation. These figures are, no doubt, based on average furnace action; variation in condition of combustion would have a corresponding effect on the efficiency of operation.

In an attempt to throw some light on this problem, I have analyzed the very excellent and important tests made by Doctor Jacobus on the large boilers in the Delray station of the Detroit Edison Co. The results, as he presented them in a paper before the American Society of Mechanical Engineers, are efficiency of operation based on coal as fired, but I have recalculated the tests on the basis of coal as burned, neglecting incomplete combustion of hydrocarbons, a small but unknown quantity. Only those tests for which a heat balance was made are available. The result is shown in the accompanying diagram. Two curves have been drawn. The broken one best fits the points, and shows efficiency declining as capacity increases throughout the full range of tests.

Unfortunately, however, for this version of the matter, extending the curve to zero evaporation, at which point the gases would leave at steam temperature, it intersects the ordinate of zero capacity at an impossible efficiency. If in drawing the curve, it is started at 88 per cent. efficiency, certainly as high as permissible, it necessarily takes the form of the full line, indicating that efficiency becomes constant at an evaporation of four pounds.

I feel that we should not condemn this work of the Bureau of Mines unless there is more ground for it than critics have yet advanced. If the full-line curve in this diagram presents the truth, it is certainly a matter of the greatest economic importance, so great in fact that if the the whole cost of the Bureau of Mines to date be charged to this one investigation, it would be had at low price.

Ample corroborative proof is available for the support of all claims of the authors of Bulletin 18, except that of a constant efficiency, and while my diagram is not conclusive, I hope this discussion may lead to further study of the matter.

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Chicago Federal Plant

During the Taft administration experts investigated the possible saving to the government by furnishing its own light and power as well as its heat in the federal building in Chicago, containing the post office.

Although their report indicated that $10,000 a year could be saved, political influence and a proposal from the Commonwealth Edison Co. to reduce the charge led Secretary MacVeagh to pass the question to Secretary McAdoo. The latter has shown his decision by awarding a contract to the Harrisburg Foundry & Machine Works for the engines and generators at a cost of $42,000. This is taken to be a declaration of the present administration's policy in matters of the kind and it is anticipated that there will be many more additions to the number of plants already operated by the government.

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Many engineers assume that most boiler explosions are caused by some mysterious influence which cannot be foreseen or guarded against, but as a fact, a definite cause can be given for most explosions of considerable violence. That a larger percentage of boiler explosions are due to causes that might have been foreseen and prevented, is a well established fact.—"Southern Engineer."

American Order of Steam Engineers Convention

The twenty-seventh annual convention of the American Order of Steam Engineers and the eighth annual exhibition of the American Supply Men's Association were held in Odd Fellows Temple, Philadelphia, Penn., June 2 to 6.

THE DELEGATES AT THE PHILADELPHIA CONVENTION OF THE A. O. S. E.

On Monday morning there was a session of the supreme council and the delegates were seated. Hon. Rudolph Blankenburg, mayor of Philadelphia, officially opened the convention and the exhibition in the evening.

After a brief session on Tuesday, an enjoyable boat trip on the steamer "Thomas Clyde" was taken, the party returning to the city at 6 o'clock.

There were two official sessions on Wednesday, and in the evening at 8 o'clock a reception and entertainment were given under the auspices of the American Supply Men's Association. This proved a most enjoyable affair and was well attended.

Thursday afternoon's program included a trolley trip and outing to Maple Grove Park, with the usual athletic events and amusements. An interesting feature was the ball game between the engineers and the supply men. The engineers won, the score being 9 to 7.

On Friday evening the closing session of the supreme council was held. The following supreme officers were elected for the coming year:

Chief engineer, George W. Goodwin, Baltimore; first assistant engineer, Harry Tallifeare, Atlanta; recording engineer, William A. Hardin, Atlantic City, N. J.; correspondent, Edward Reboul, Germantown, Penn.; treasurer engineer, Michael Helmstreit, Philadelphia, Penn. senior master mechanic, Daniel Buntin, Philadelphia Penn.; junior master mechanic, Charles O. M. Bear, Allentown, Penn.; chaplain, L. J. Callaway, Philadelphia

THE SUPPLY MEN AND GUESTS AT THE CONVENTION

Penn.; inside sentinel, Philip Kirkwood, Baltimore; outside sentinel, Henry Messer, Columbia, Penn.; trustee B. B. Heilman, Reading, Penn.

The next convention will be held in Baltimore.

The American Supply Men's Association elected the following officers: President, Fred L. Jahn; vice-president, Harry Souders; secretary, Charles A. Wilhoft; treasurer, John W. Armour; chairman of executive committee, Frank Martin; director of exhibits, Hart Hill.

The exhibitors were: Albany Lubricating Co., Anchor Packing Co., Armstrong Cork Co., Baseler & Heinecken, Inc., S. F. Bowser & Co., Inc., F. H. Brown Packing Co., Buhne Metal Packing Co., Collieries Supply & Equipment Co., Cyrus Borgner Co., James V. Colpitts, Dearborn Chemical Co., Diamond Power Specialty Co., Joseph Dixon Crucible Co., R. & J. Dick, Ltd., Duemler & Co., Economy Fuse & Manufacturing Co., Engineering Supply Co., Fairbanks Co., Fisher Governor Co., Ford & Kendig, France Packing Co., Frick Grate Co., Garlock Packing Co., Greene, Tweed & Co., Griscom-Russell Co., Hawkeye Compound Co., Home Rubber Co., E. F. Houghton & Co., Paul B. Huyette Co., Inc., Hazard Manufacturing Co., Jenkins Bros., H. W. Johns-Manville Co., Kelly & Jones Co., Keystone Lubricating Co., Leavitt Machine Co., Local Steam Packing Co., the Lunkenheimer Co., Lagonda Manufacturing Co., McArdle & Cooney, McLeod & Henry Co., National Tube Co., Nelson Valve Co., George B. Newton Coal Co., New York Belting & Packing Co., POWER, Philadelphia Grease Manufacturing Co., Peerless Rubber Manufacturing Co., Philadelphia Bourse, *Popular Engineer*, Quaker City Rubber Co., E. J. Rooksby & Co., William C. Robinson & Sons Co., Frank H. Stewart, Schade Valve Co., Joseph F. Schiller, C. E. Squires Co., *Southern Engineer*, Texas Co., Travelers Indemnity Co., Trill Indicator Co., U. S. Graphite Co., H. B. Underwood Co., Vacuum Oil Co., Thomas C. Warley & Co., Watson & McDaniel Co., Elisha Webb & Son Co., Washburn & Granger, Samuel T. Wilson, Yarnall-Waring Co., Warren Webster & Co., Zurn Oil Co.

Illinois State N. A. S. E. Convention

The ninth annual convention of the Illinois State Association of the National Association of Stationary Engineers was held at Rockford on May 28, 29 and 30.

At the opening session on Wednesday, Rev. F. W. Lynch pronounced the invocation, followed by Mayor W. W. Bennett's address of welcome. National President John F. McGrath responded and other appropriate speeches were made by F. E. Carpenter, National Secretary Raven, John W. Lane, editor of the "National Engineer," and W. L. Osborne, president of the Central States Exhibitors' Association. State President John Morgan was then introduced and having called the convention to order appointed the various committees.

After the brief executive session in the evening the delegates joined the visitors at the Armory where the exhibit of the thirty-odd members of the exhibitors' association was held and an impromptu entertainment was given.

Following the business session on Thursday morning the delegates and visitors enjoyed an automobile ride to the several beautiful parks and other points of local interest. In the afternoon an excursion on the steamboat "Illinois" was taken to a grove 8 miles up the Rock River where a baseball game between the engineers and supplymen was settled in favor of the former with a score of 8 to 3. The winners are entitled to retain for another year the silver loving-cup trophy which was donated by the Supply Men's Association a year ago and which was won by the Chicago Engineers' Visiting Club last fall.

On Thursday evening, Prof. D. R. Mead, of the University of Wisconsin, was to have given a lecture on "Hydro-Electric Developments," but as he was unavoidably called away, Os-

DELEGATES AND GUESTS OF THE ILLINOIS STATE N. A. S. E. CONVENTION

born Monnett, chief smoke inspector of Chicago, lectured on "Smoke Prevention" instead.

The annual election of officers was held on Friday morning, resulting in the choice of the following: W. E. Hill, Rock Island, president; Fred G. Weller, Peoria, vice-president; G. Anderson, Chicago, secretary-treasurer; Henry Misostow, Chicago, state deputy.

The next convention will be held in Peoria.

⁂

Indiana N. A. S. E. Convention

The Indiana State Association of the National Association of Stationary Engineers held its ninth annual convention in Terre Haute on June 4, 5 and 6, with the Filbeck Hotel for headquarters. The mechanical exhibit by the Central States Exhibitors' Association and the convention sessions were held in the Knights of Pythias Temple. The first session was called to order by H. E. Smith, chairman of the local committee, at 9:30 a.m., Wednesday. Mayor Louis Gerhardt then welcomed the delegates and visitors to the city and National President John F. McGrath responded. After appropriate speeches by H. R. Ihrie, secretary of the Terre Haute Commercial Club, National Secretary Fred Raven and others, the supplymen's exhibit was formally opened by President Osborne, and a brief address was made by Past National President Charles W. Naylor.

In the afternoon visits were paid to the water works, the American Hominy Mills, the light and power station and the Prox Machine Co. In the evening Prof. F. Wagner, of the Rose Polytechnic Institute, gave an illustrated lecture on "Steam Turbines"

At the Friday morning session the following officers were elected: President, George R. Fields, Terre Haute; vice-president, Louis Minke, Evansville; secretary, Albert Franke, Terre Haute; treasurer, A. T. Arens, South Bend.

In the afternoon the delegates, visitors and supplymen enjoyed a 30-mile boat ride on the Wabash River; a fish fry was served on the boat.

⁂

Stevens Institute's Forty-First Commencement

The forty-first commencement of Stevens Institute of Technology, Hoboken, N. J., took place on June 10. Sixty-five men were graduated, each receiving the degree of mechanical engineer, the only degree conferred upon graduation.

The valedictory address was delivered by Jerome Strauss, of Brooklyn, N. Y., who was also honored with the distinction of winning the Stillman Prize in Applied Technology, which is annually awarded to the member of the senior class who prepares the best paper on a subject pertaining to applied technology. The subject for the prize paper selected by the Committee of the Faculty and open to competition among members of this year's graduating class was, "Advantages and Applications of the Low-pressure Steam Turbine."

Believing that our readers would be interested in reviewing Mr. Strauss' paper, we have arranged to publish an abstract of the same in an early issue of "Power."

⁂

Government Light and Power Plant for Chicago Post Office

Secretary McAdoo, of the Treasury Department, on June 2, ordered the installation of the Government's own lighting and power plant in the Chicago post-office building.

This action, ending a long controversy between the Treasury Department and a private contractor as to the ability of the Government to make a saving through the operation of its own plant, forecasts the possible extension of the policy to Federal buildings in other big cities, especially New York.

⁂

For Protection of Electric-Service Employees

The following requirements for the protection of employees of all public-service corporations in the jurisdiction of the Public Service Commission, First District (New York City), will be in force on and after July 1:

(1) All high-tension switch compartments shall, so far as their construction will permit, be so inclosed as to make it impossible, except when necessarily opening the compartments, for employees to come in contact with electrically charged parts either from or above the floor level.

(2) All exposed high-tension cables in power or substations shall be inclosed by screens or otherwise protected.

(3) There shall be posted, in conspicuous places in all the power houses and substations, diagrams describing and showing the relative location of wires and cables (except lighting and signal wires) and the switches, etc., controlling them and all such wires, cables and connections shall be so tagged and numbered that they may be readily identified.

(4) All machines for the generation of current or connected with such generation shall be so protected by railings and gratings as to safeguard operators and others from coming in contact with moving or electrically charged parts.

(5) There shall be at least two operators on duty in rotary-transformer stations delivering current at 500 volts or higher when the same are in operation.

(6) All water-level glasses or gage-glasses on tanks, standpipes, or other storage receivers under pressure, shall be protected by screens to prevent injury in case of a bursting glass.

(7) Test cocks on water columns shall be fitted with extension rods or chains so as to be operative from the boiler-room floor level.

(8) All stop valves on steam boilers shall be of the automatic self-closing type.

(9) Outlets of all safety valves shall be vertical.

(10) All furnace doors on hand-fired boilers shall be fitted with latches or catches to prevent them from being blown open.

(11) All moving parts of stokers shall be so protected, wherever possible, as to prevent accidental contact with such moving parts.

(12) All large main cutout stop valves shall be provided with means whereby the same may be closed from the boiler or engine-room floor or other remote point.

(13) All large steam units shall be fitted with automatic self-closing valves.

(14) All high-speed engines shall be fitted with automatic safety stops.

(15) Elevator wells shall be properly and substantially inclosed, secured or guarded and shall be provided with proper traps and automatic doors in or at all elevator ways so as to furnish substantial covering when closed and to open and close by action of the elevator when ascending or descending.

(16) All openings in floors shall be roped off or protected by railings when left unguarded, and, in addition, a red light shall be hung in the immediate vicinity when the location is unlighted or poorly lighted.

(17) All stairways shall be provided with safety treads, kept free from oil and water and be properly protected with hand-rails.

(18) Shafting running along or passing through floors shall be housed or screened or otherwise properly guarded.

(19) All belting shall be inclosed or otherwise protected wherever accidental contact is possible.

(20) Gear-case covers completely inclosing the gears shall be fitted to all machine tools and be kept in place while such tools are being used.

(21) Set screws and keys in exposed positions on moving machinery and shafting shall be countersunk or otherwise properly protected.

(22) Buzz saws and band saws shall be protected so as to prevent accidental contact with saw blades.

(23) Grinding and emery wheels shall be properly guarded and equipped with hoods and exhaust pipes to draw off finely powdered material.

(24) Guard glasses shall be provided for employees and used by them when engaged upon any work causing chips or fragments to fly, and wire screens of a portable or permanent type shall be set up on work benches or around employees engaged in chipping.

(25) A sufficient number of pails of clean, dry sand must be kept in all power stations, substations, auxiliary and switching stations.

(26) Power stations, substations, auxiliary and switching stations shall be provided with a sufficient number of chemical fire extinguishers of such a type that the contents cannot act as an electrical conductor. No other extinguishers shall be kept for use unless conspicuously labeled that they are not to be used until current has been shut off.

(27) All power stations, substations, auxiliary and switching stations and shops shall be provided with a first-aid or emergency kit.

(28) Provision shall be made whereby pulmotors will be available in case of accidents.

And it is further ordered that on or before June 1, 1913, said companies and said receivers adopt, promulgate and thereafter rigidly enforce rules and regulations to govern their employees in the handling of high-tension apparatus and in the handling of steam and mechanical apparatus in power stations, substations and shops.

SOCIETY NOTES

The next annual meeting of the National Conservation Congress will be held in Washington, D. C., Nov. 18, 19 and 20. Especial importance attaches to the selection of Washington for the reason that certain private interests opposed to conservation have recently sought to make it appear that there is lack of harmony between the Conservation Congress and the Conservation Association. That Washington was chosen after consultation between officers of both organizations shows that the congress and the association are working as a unit with identical aims. There are already indications of a record attendance.

Under the active administration of President Charles Lathrop Pack, the work of the National Conservation Congress is making gratifying headway. One of his most important steps was the appointment of a forestry committee of which the chairman is Henry S. Graves, Chief Forester of the United States Government. The work is being briskly advanced by this committee.

An important phase of conservation to be considered at the Washington meeting involves the tremendous fire waste in the cities of America. At the request of the National Board of Fire Underwriters, the Executive Committee has agreed to give place on the program for discussion of this momentous question. The vast loss to the country through preventable fires will be shown in concrete and comprehensive form and means will be considered for minimizing this unnecessary waste.

"Undoubtedly, the live questions of forestry and water power will dominate this year's congress," said President Pack. "Already the lines are being drawn for a fight. This is shown by misleading reports which the common enemy of conservation have been scattering to the effect that there might not be harmony between ourselves. As to water power, the Conservation Congress has always held that the remaining sites in the hands of the Federal Government should not in any way pass to the use of private interests without safeguarding the treasure now the property of the people. The report of the able committee on water power will be awaited with great interest. They are to report at the November meeting in Washington."

PERSONALS

I. Mhyre Hofstad, St. Petersburg, Alaska, has been appointed agent for that territory for the Blanchard Machine Co., Cambridge, Mass., manufacturers of oil engines, marine and stationary.

John Kollin, for several years sales manager with the Patterson-Allen Engineering Co., has been appointed general manager of the Monarch Specialty Manufacturing Co., New York City, which manufactures and deals in engineering specialties.

H. L. Watson, a member of the American Society of Mechanical Engineers, formerly sales engineer with the Allis-Chalmers Manufacturing Co., Milwaukee, has accepted the position of sales manager for the De Laval Steam Turbine Co., Trenton, N. J.

H. P. Bouslog, formerly chief engineer of the lighting plant of the Interstate Public Service Co. Shelbyville, Ind., has been appointed chief engineer of the power station of the interurban lines of that company, formerly the Indianapolis, Columbus & Southern Traction Co., at Edinburg, Ind., to succeed Levi Crater, who has resigned.

John R. Wilde has been appointed chief engineer of power plants for the Detroit Edison Co., succeeding B. J. Denman, who resigned May 1 to take up executive duties with the United Light & Rys. Co. at Davenport, Ia. Mr. Wilde has been in the service of the Detroit company for a number of years. J. W. Parker has also been appointed chief assistant engineer of power plants, sharing with Mr. Wilde the duties formerly discharged by Mr. Denman.

F. R. Low, editor of "Power," sailed for Germany, June 10, on the "Victoria Luise," of the Hamburg-American Line. He is a member of the official party of the American Society of Mechanical Engineers on its way to attend the joint meeting with the German national engineering society, the Verein Deutscher Ingenieure. Mr. Low is accompanied by Mrs. Low and their son, Giles, and will visit a number of the principal industrial cities in Germany, Great Britain, Switzerland and France before returning to New York the last of August.

Charles A. Carels, chairman of the board of directors of Carels Frères, of Ghent, Belgium, is visiting the United States to arrange for the manufacture of the Carels-Diesel engine in this country. Mr. Carels, as representative of his associates, says they are very strong believers in the possibility of the development of the Diesel engine in the United States and of its commercial future. They have recently employed D. G. Baker, an American engineer, as director-general of production at their plant in Ghent. Mr. Carels is visiting a number of the largest machine builders with a view of buying some additional American tools and equipment for the Ghent plant. At the present time 70 per cent. of their tools are of American manufacture. Mr. Carels is now on a trip to Cleveland, Cincinnati, Detroit and other points.

George R. Croll, general superintendent of mechanical equipment for Thomas Borthwick & Sons, Ltd., Australasia, who is on a tour in this country and Europe, recently spent a week in Chicago inspecting the meat-packing plants. He is in charge of the five Borthwick plants, two in New Zealand and three in Australia, where meats, tallow, wool, etc., are prepared for shipment to England and the Continent.

Mr. Croll stated that the operating conditions throughout Australasia compared very favorably with those prevailing in this country. The eight-hour day is universal. At the plants under his charge the entire engineering force is employed steadily through the year, although the works are shut down annually for several months. During the off-season the men are employed with repairs, renewals, etc. The men are each given a two-weeks' vacation with full pay. They obtain their meats at wholesale prices and usually have a kitchen garden near their homes. The chief engineer is provided with free electric light. All regular overtime work is paid for, but emergency overtime work is cheerfully performed by the men without pay.

As a fine spirit of fair play usually exists between employers and employees, it is not uncommon for men to spend their lives with one concern. Mr. Croll grew up in the meat-export business, starting as an apprentice in operating engineering. He has been a reader of "Power" for 23 years, and encourages his men to read it regularly by providing a copy for each plant. His object is to assist the young men to the more important positions constantly being created by the erection of additional plants. The practice of promoting men already employed by the firm prevails.

OBITUARY

BERNHARD SCHUCHARDT

Bernard Schuchardt, head of the well known firm of Schuchardt & Schütte, died in Berlin, Germany, on June 3, after a brief illness.

Mr. Schuchardt's connection with the machinery-building industry runs back over a period of some 30 years. Early in its experience as international machinery dealers his firm became an influential factor in the export trade of the American machine-tool industry and it steadily grew to include all of the principal markets of the world.

Mr. Schuchardt was consul-general to Norway in Germany and held honorary appointments from the German government. At the time of his death he was 58 years old.

The Greenfield (Mass.) Electric Light & Power Co. has contracted with the S. Morgan Smith Co. for three wicket-type turbine water wheels for general light and power service. These are to be used in the Gardner Falls Station, and the two less efficient units already there are to be used only in emergency after the new ones are installed. The latter will be the first concrete scroll case wheels in New England. Water is carried to the wheels through a concrete scroll in a manner similar to that developed in the big Keokuk power plant. Each of these units is a single vertical wheel directly connected to an umbrella type generator operating at 150 r.p.m. Each wheel is rated at 1450 hp. with a 37-ft head and is 57¼ in. in diameter. The exciter unit is vertical, of 135 hp. at 550 r.p.m., and measures 16½ in.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared by John G. Brown for the construction of a power plant at Ninth St. and Allegheny Ave., Philadelphia, Penn., for the Electric Storage Battery Co.

Plans are being prepared by the Penn Central Light & Power Co. for the construction of a new power plant at Williamsburg, Penn., to have a capacity of 30,000 hp. Warren Partridge, Clearfield, Penn., is general manager.

Plans are being considered by the Cambridge Gas, Electric Light & Power Co. for the installation of new equipment in its power plant at Cambridge, Md. G. Lobo is secretary.

SOUTHERN STATES

Stanley Scott and associates contemplate the construction of an electric-light plant at Eastville, Va.

The Southern Utilities Co., Jacksonville, Fla., is considering plans for the improvement of its various plants. H. C. Adams, Jacksonville, is manager.

Bonds to the amount of $5000 have been voted for the installation of a water system in Passagrille, Fla.

The Ballard & Ballard Co., a Louisville, Ky., is contemplating adding to its electrical equipment by the installation units aggregating 200 hp.

CENTRAL STATES

The Coshocton Light & Heating Co., Coshocton, Ohio, is considering the installation of additional equipment in its plant. C. H. Howell is superintendent.

An election will be held soon at which the proposition to issue $125,000 for the construction of a municipal electric-light plant at Lancaster, Ohio, will be submitted to the voters.

Boilers and other power equimpent will be purchased by the Wood Mosaic Co., New Albany, Ind., for installation in its new sawmill at Highland Park, Ky. The power plant of the mill which was recently destroyed was a total loss.

The city of Portland, Ind., contemplates an expenditure of $4000 for the installation of a new boiler in the municipal electric-light plant. O. O. Clayton is city engineer.

The village of Ahmeek, Mich., contemplates the installation of a water system, to cost $9000.

Bids will be received by Homer Fish, village clerk, Saline, Mich., until June 18, for the construction of a water system. Estimated cost, $30,000. Plans have been prepared by the W. J. Sherman Co., The Nasby, Toledo, Ohio.

Frugale Power Co. is considering plans for the construction of a power plant at Whitehall, Mich. Estimated cost from $15,000 to $20,000. Frank H. Speese is engineer-in-charge.

Plans are being prepared by the Lewistown Electric Co., Lewistown, Ill., for the installation of additional equipment in its power plant. C. W. King is general manager.

Plans have been prepared by Herman Azzaline, Sr., for the construction of an electric-light plant at Hollandale, Wis.

WEST OF THE MISSISSIPPI

W. T. McVasky & Co. is considering the construction of an electric-light plant at Belmont, Iowa.

The Holstein Service Co. contemplates the construction of an electric-light plant at Holstein, Iowa. W. F. Hutton is secretary.

W. A. Curtis contemplates the installation of an electric-light plant at Maxwell, Iowa.

The Mediapolis Electric Co. has been granted a franchise to construct and operate an electric-light plant at Mediapolis, Iowa.

At a recent election it was voted to construct a municipal electric-light plant, at Russell, Iowa.

On May 24 the electric-light plant of the Warfield Electric Co., at Bemidji, Minn., was destroyed.

Bonds for $30,000 have been voted for the construction of an electric-light plant and water system at Warroad, Minn.

WANTS

Positions Wanted, three cents per word, each insertion
Positions Open, five " " " " "
For Sale, five " " " " "
Miscellaneous, ten " " " " "
No abbreviated words allowed.
Count three words for keyed address.
All advertisements payable in advance.

Copy should reach us not later than Tuesday 10 A. M., for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, will be forwarded.
No information given by us regarding any advertiser's address. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondent.
No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for positions.

POSITIONS OPEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M.M. Co.," Power.

CHIEF ENGINEER for central station of about 10,000 kw. capacity in the East; turbines and reciprocating engines; must be able to handle men, keep plant details of experience and state minimum salary. P. O. 911, Power.

A HUSTLER, well known to structural-steel engineers and contractors, to sell high-grade metal paint; acceptable opening for an energetic man who can get results. The Atlas Paint Co., 101 Park Ave., N. Y. (Apply in forenoon.)

AGENTS to sell on commission mechanical draft blowers; prefer men who handle on similar basis sales of grate bars, tube cleaners or other boiler accessories; hustlers wanted; state experience and territory worked. P. 855, Power.

AT ONCE, TWO GOOD ENGINEERS and one chief engineer for 1500-hp. electric light and power plant located in Pennsylvania; applicants must be familiar with turbines and switchboards; state experience, age and salary expected in first letter. P. O. 910, Power.

POSITIONS WANTED

ERECTING FLOOR FOREMAN by an erecting engineer, at present employed on large size units. P. W. 916, Power.

BY LICENSED STEAM ENGINEER, refrigerating or electric; best of experience and reference; executive ability; now employed. P. W. 909, Power.

A TECHNICAL MAN wants position as superintendent of an electric-lighting and refrigerating plant; age 34; good reasons for changing. P. W. 915, Power.

NEW YORK REPRESENTATIVE OF STEAM SPECIALTIES wishes some more representations, also sole agencies of England. Gillett, 301 West 17th St., New York.

DISTRICT STEAM HEATING thoroughly understood by practical mechanic; at present in charge of steam and condensation meter department, desires to make change. P. W. 918, Power.

CHIEF ENGINEER; will be open July 1; 13 years' experience in railway power plant, eight years in manufacturing plant; strictly sober; can refer to present employer. P. W. 913, Power.

A MECHANICAL ENGINEERING GRADUATE wants position as superintendent of power, or master mechanic with a manufacturing firm; 11 years' varied experience; now employed. P. W. 914, Power.

BY AN ELECTRICAL, MECHANICAL AND EFFICIENCY ENGINEER, who has had 20 years' experience in teaching, designing, constructing, operating and managing; graduate Cornell, and member American Society of Mechanical Engineers. P. W. 912, Power.

MANUFACTURERS REPRESENTATIVE, favorably known and of wide experience in modern engineering, wishes to handle power-plant equipment, engines, boilers, stokers, etc., in Pittsburgh district. Daniel Ashworth, M. E., 1225 Fulton Bldg., Pittsburgh, Penn.

REFRIGERATION ENGINEER, total abstainer, has served two years as chief, desires position as chief in either absorption or compression plant; good boiler economy and machine capacity guaranteed; Middle West or South preferred; less than $125 not considered; good references. P. W. 906, Power.

FOR SALE

22x48 BROWN CORLISS TYPE ENGINE, perfect condition. $675. Duzets & Son, Hudson Terminal, New York.

20x42 HUGHES & PHILLIPS tangye frame Corliss engine; cost $4000; like new; $1200. Duzets & Son, Hudson Terminal, New York.

20x42 LANE & BODLEY HEAVY DUTY CORLISS ENGINE; condition like new; $900. Eastern Machinery Exchange, 171 Broadway, New York.

GAS ENGINE, 225 hp. American Crossley horizontal double cylinder, opposed 22x30 in., with Akerlund producer; located Columbia, S. C.; selling account cheap hydro-electric power; bargain. F. S. 904, Power.

ENGINES AND BOILERS, 12x36 St. Louis Cor., 14x36 St. Louis Cor., 26x48 Fil. & S., 26x42x48 Cross Compound, $1400, 2-250 HP. Heine Boilers, 2-180 HP. Heine Boilers, 2-72x18 Boilers. Send for complete list of Engines, Boilers, Generators, Motors, etc. Harold R. Wilson Machinery Co., St. Louis.

GAS ENGINE—One Foos vertical 15x20-in. three-cylinder producer-gas engine, 150 brake hp., speed 225 r.p.m., connected to S-5½-E, 100 kw., 250-volt, compound-wound, direct-current Western Electric generator with field rheostat; approximate weight, 49,000 lb.; good condition; very moderate use for about two years. F. S. 917, Power.

ONE 10x16-IN IDEAL TANDEM COMPOUND CENTER CRANK STEAM ENGINE, 100 i.hp. at 270 r.p.m.; high-pressure cylinder has piston valve, low-pressure cylinder, balanced slide valve, operated from inertia type shaft governor; flywheel 5 ft. 8 in., 15-in. face; steam pipe, 4 in.; exhaust, 5 in.; shaft, 5½ in.; over-all dimensions, 5x11 ft. 7 in.; one 10x9 simple junior Westinghouse engine; capacity, 50 i.hp. at 335 r.p.m.; flywheel, 3 ft. 6 in. diameter, no belt wheel; steam pipe 3½ in.; exhaust 4 in.; shaft, 3⅜ in.; over-all dimensions, 3 ft. 8 in. by 7 ft. 2 in. For further information concerning these engines address James M. White, supervising architect, University of Illinois, Urbana, Ill.

MISCELLANEOUS

PATENTS SECURED—C. L. Parker, Patents 904 G St., Washington, D. C.

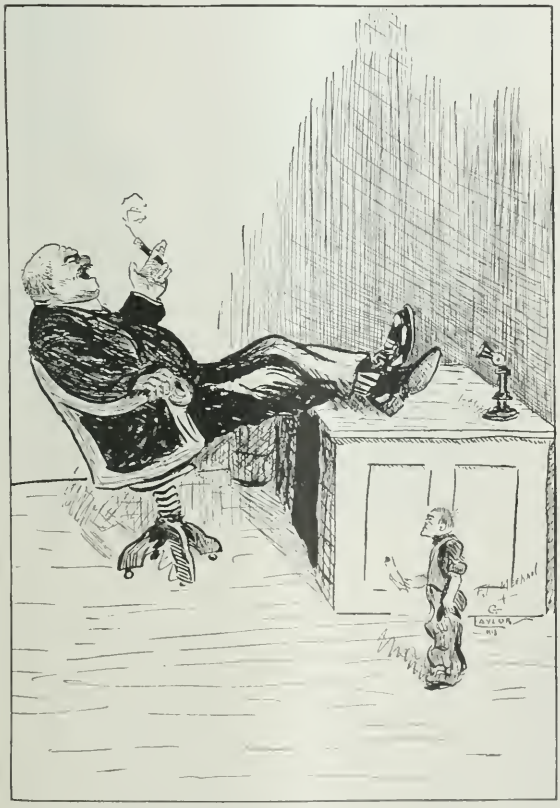
WANTED—One 350- to 400-hp. high-pressure boiler. Address Wausau Box & Lumber Co., Wausau, Wis.

WANTED—Additional capital for Lawrence Mfg. Co., lately incorporated to manufacture and exploit new inventions patented in the U. S., Canada and England; for particulars address: Lawrence Mfg. Co., Key West, Fla., or George Hiram Mann., 71 Wall St., New York.

POWER

Vol. 37 NEW YORK, JUNE 24, 1913 No. 25

"Circumstances Alter Cases"



AS THE ENGINEER APPEARS TO THE OWNER WHEN HE SUGGESTS MEANS OF IMPROVING THE PLANT

AS THE ENGINEER APPEARS TO THE OWNER WHEN ANYTHING GOES WRONG WITH THE MOTIVE POWER

Power Plant of Woolworth Building

By Thomas Wilson

SYNOPSIS—Six water-tube boilers of 2454 hp. capacity supply steam to four tandem-compound generating units which furnish electrical energy to thousands of lights, 27 traction elevators, motors on the ventilation and for other purposes, and exhaust steam for 104,000 sq.ft. of radiating surface supplied by a return-line vacuum system. Features are the provisions for safety on the elevators and the partial condensation of steam from the free exhaust. The remaining vapor is passed into the smoke flue and from the exterior no steam is visible.

The world's greatest office building, the Woolworth, rising 910 ft. above bed rock, or 780 ft. above the curb, is without question the most impressive architectural structure in New York or any other city. With an exterior of creamy-white stone and terra cotta it is visible miles from the city and at night the lighting features are specially attractive. Throughout the main part, the design is a combination of Italian, French and modern Renaissance with Gothic steeples at the roof. Marble of many varieties, steel, bronze and wire glass trim the interior, and in the arcade the design and decorations are magnificent.

Fig. 1. The Woolworth Building

For a building of such mammoth proportions a few popular figures concerning the construction may be of interest. When it is considered that 24,000 tons of steel, 17,000,000 bricks, 50,000 cu.yd. of sand, 15,000 cu.yd. of broken stone, 7500 tons of terra cotta on the exterior and 28,000 tons on the interior for partitions, etc., 53,000 lb. of bronze and iron hardware, 383,325 lb. of red lead, 3000 hollow steel doors, and over 3000 exterior windows were used, some idea of the work involved may be obtained. There are 87 miles of electric wiring, 43 miles of plumbing pipe, 12 miles of marble trim and 12 miles of slate base.

Fig. 2. One Side of the Firing Alley in the Boiler Room

The main part of the building has a base area of about 153x197 ft. It is 29 stories high and its contents is 13,200,000 cu.ft. The tower is 84x86 ft. and its top floor is the fifty-fifth story above the curb. In acres the rentable office space totals 27, and elevators and corridors take 13 more. The total weight at the caissons is 206,000,000 lb. and the cost of the building completed, about $13,000,000.

The plant apparatus installed for the purpose of furnishing power, light, heat, ventilation and refrigeration for this magnificent building represents good office-building practice. The arrangement, as seen by the accompanying plan, is compact and convenient. The appurtenances and piping constituting the central plant are, so to speak, woven in among the foundations and construction work supporting the gigantic superstructure. An impression one receives when first entering the sub-basement is that too little space has been allotted for the mechanical equipment, but this impression is gradually removed when the visitor stops and observes that there is a space for

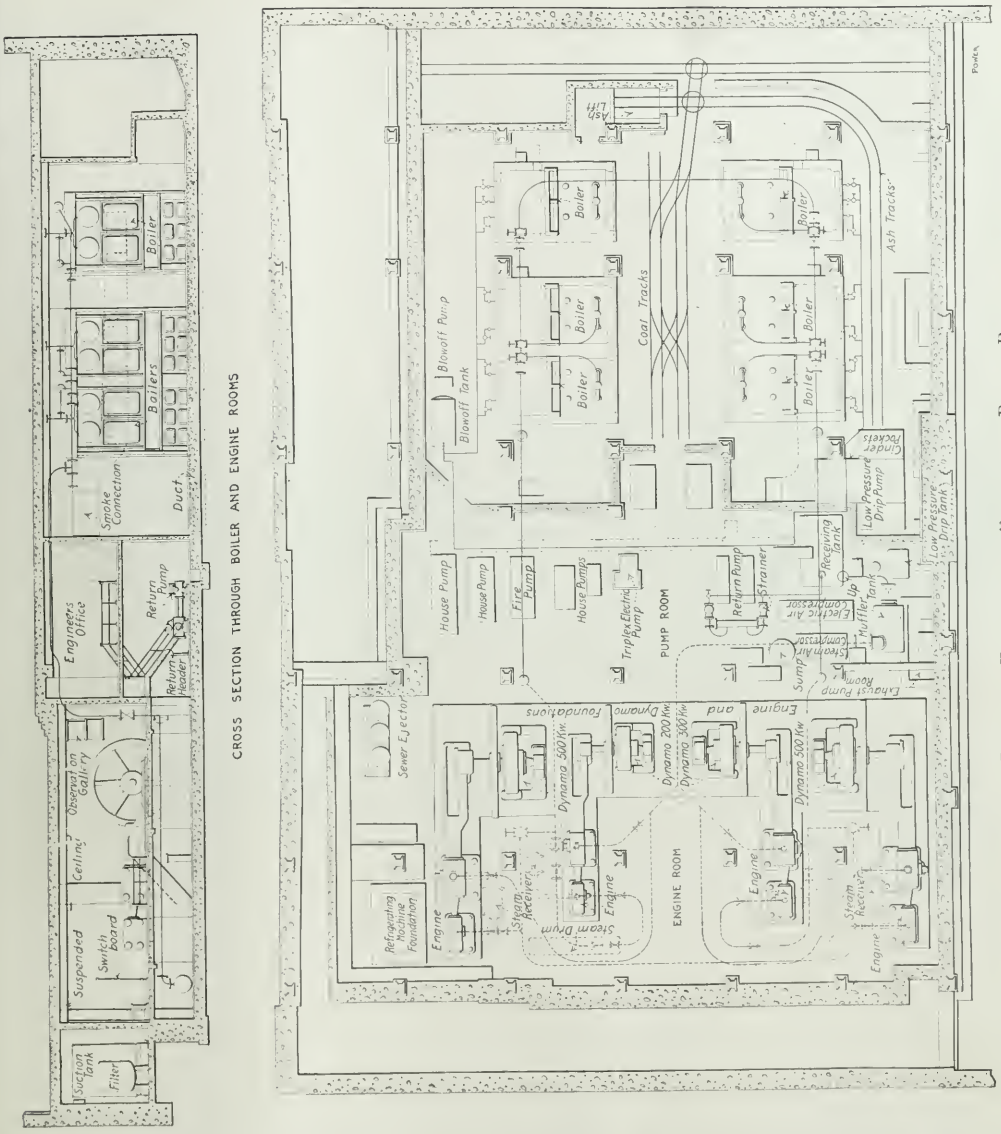


FIG. 3. PLAN AND ELEVATION OF ENGINE AND BOILER ROOMS

everything and everything is in its place in a manner which permits both inspection and repairs when needed, and affords an unhampered freedom for effective operation.

THE BOILER PLANT

Six B. & W. boilers, rated at 2454 hp. capacity, are installed and equipped to generate steam at high pressure. The boilers have wrought-steel headers and each is composed of two 12-in. steam and water drums, one wrought-steel mud drum and a set of tube sections having 12 tubes each, 4 in. in diameter and 18 ft. long. Four of the boilers are built up of 16 tube sections and two have 18 sections. The four 16-section boilers are set in batteries of two, and the wider boilers are set singly. The boilers are suspended on steel framing independent of the brick settings. Provisions are made in the settings for forced-blast installation, and the boilers are so hung that mechanical stokers can be installed whenever such will be required to burn bituminous coal. For the present Treadkill dumping grates are provided and the boilers are hand fired with anthracite coal.

The smoke flue is 6 ft. 6 in. in diameter and over 700 ft. high. It terminates in one of the corner towers where the products of combustion are discharged through openings around the peak of this tower. These openings are

worked into the design in such manner that they are invisible from the street.

The draft is powerful on account of the great height, and as a special means for preventing an undue amount of ashes and cinders from being carried up and discharged into the atmosphere, as frequently is the case in high buildings, settling chambers are provided in the horizontal smoke connections in the sub-basement. There are two of these settling chambers or pockets, one for each side of the boiler room. Each pocket is in the form of an enlargement of the smoke connection, in which V-shaped baffles are suspended, against which the cinders are cast by the force of the draft and thus intercepted and caused to settle down into the bottom pan of the pocket, from which they can be readily removed.

In connection with the disposal of the products of combustion there is also another and distinctly novel feature in the way in which the steam from the free exhaust pipe is made to disappear. The principle is as simple as it is effective, and fails only at such intervals when the draft is checked by the damper regulator. The exhaust steam is discharged to the atmosphere with the hot chimney gases, with the result that the steam is made invisible as long as there are flue gases of sufficient heat and volume. The mixing of the two products is accomplished at the forty-sixth story, where the smoke flue and the free exhaust both had to be transferred horizontally on account of structural features. The exhaust steam is in this story passed through a condenser tank somewhat in the form of a return-tubular boiler, over the shell and through the tubes of which air is drawn by a fan for the purpose of condensing as much of the steam as possible, the remaining vapor being passed directly into the smoke flue and mixed with the chimney gases in their transit to the atmosphere.

The coal storage is located below the sidewalk and has a capacity of 750 tons. The coal is brought to the boilers in charging cars run on an industrial railway. The ash hoist is located on the same side, and the ashes from the boilers as well as the cinders from the settling chambers are taken in barrels on flat top cars to the ash lift and raised to the sidewalk.

Boiler-Room Auxiliaries

The auxiliaries to the boiler plant are situated in the two-story pump room immediately adjoining the boiler room, and between it and the engine room. Here, at the boiler-room level, are located two 12 and 7½ by 15-in. Worthington horizontal feed pumps, of the outside-packed plunger pattern; the house and fire pumps, five steam and one electrically driven; two steam-driven sump pumps; one steam and one electric air compressors for the sewage ejectors; the muffler tank for the 22-in. main exhaust line from the generator engines; the low-pressure drip tank and pump, the two vacuum-return pumps and the receiving tank for the returns from the heating system. The blowoff pump with its tank is located in the boiler room.

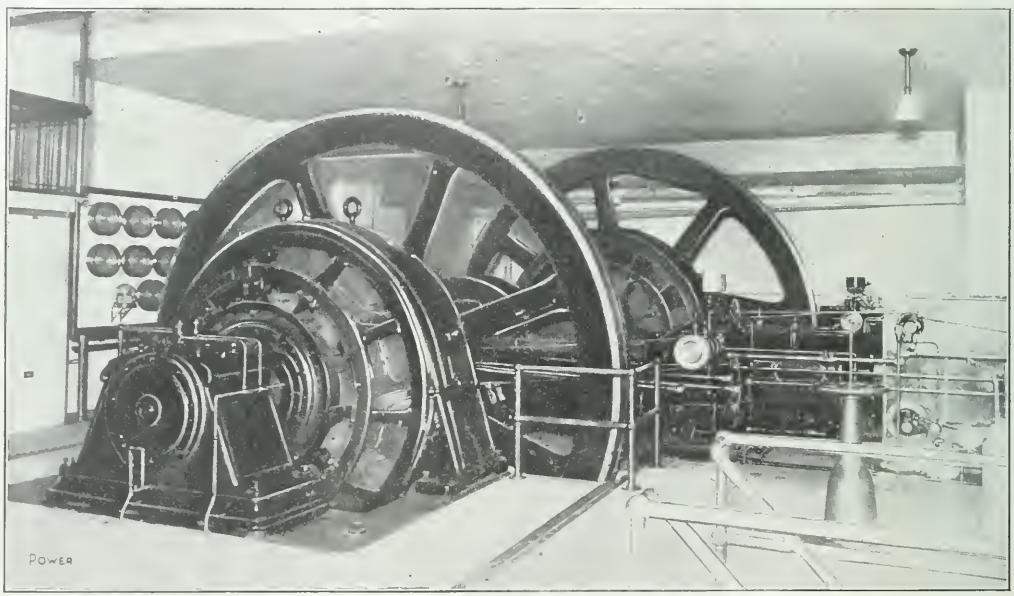


Fig. 4. Generator End of Two of the Larger Units

On the upper level of the pump room are located two Blackburn-Smith feed-water filters; one Reilly multicoil feed-water heater; one Worthington feed-water meter; eight heaters for the hot-water service of the plumbing system; the grease-extractor tank for the 12-in. exhaust line supplying steam to the hot-water heaters and the tempering coils; two air compressors for the automatic heat control; two steam-driven circulating pumps for the plumbing system; two electrically driven air compressors for the pneumatic message system; and several ventilating fans, as well as the engineer's office, which is at a higher level than the engine room.

Engine Room

The engine room contains, besides the electric-generating plant and the switchboard, a 20-ton refrigerating machine of the compression type. The electric-generating plant is made up of four direct-connected units, of which two are of 500 kw., one of 300 kw. and one of 200 kw. capacity. The engines are of the Rice & Sargent tandem

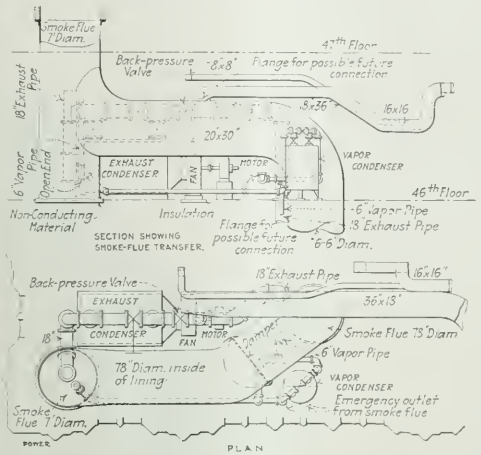


Fig. 5. Condensing the Steam from the Free Exhaust

compound type, and run at 100 r.p.m. The dynamos, as well as the balancer sets, of which there are three, are General Electric.

Directly opposite the switchboard and about on a level with the chief engineer's office is an observation gallery, inclosed in glass, which overlooks the entire engine room. The engine room is finished in white and tiled on both walls and floor, which finish, together with the copper trimmings on the switchboard and the polished-metal surfaces on the machinery, presents an attractive appearance. No pipe work or ducts are visible in the engine room, all being concealed in the suspended ceiling over this room and in the pipe cellar underneath. A clear head room of 13 ft. exists practically throughout.

Piping

Both the power main and the feed main are run on the loop principle. The feed main, which is 5 in. in diameter, is made of brass pipe, so valved that the boilers can be fed in either or both directions of the circuit, making it possible in the event of a break in this line to shut off any section for repairs. In addition to this, an auxiliary cold-water feed line is provided through which the boilers can be filled and washed when desired, as well as fed through the injectors should the regular feed line or feed pumps be out of commission. All the feed piping is covered with nonconducting material except the individual branches connecting with the boilers, which are made up of polished pipe and fittings.

The main power line is arranged on the same principle, with valves placed in the run at intervals to permit cutting out any desired section in case of repairs. In addition to the hand valves each branch from the boilers connecting with the main power line has also been provided with a triple-duty emergency stop and check valve. All branches leading from this main have in no case less than two valves. The portion of the power main within the engine-room section is carried through the pipe spaces beneath the engine-room floor, where connections are taken off to two steam-distributing drums through which the engines are supplied with steam. Each of these drums is 33 in. in diameter and 15 ft. long, built of openhearth steel with triple-riveted butt-strapped seams and anchored to concrete foundations. All valves on the connections to and from the drums, as well as the valves on the exhaust pipes, which are also located in the pipe cellar, are provided with floor stands for operation from the engine-room floor.

All high-pressure steam pipes 5 in. in diameter and over are made up of standard full-weight steel pipe with Van Stone flanged ends and heavy rolled-steel flanges and fittings of extra-heavy gun iron. All smaller high-pressure steam pipes are made up of extra-strong wrought-iron pipe with heavy cast-iron fittings. All large exhaust pipes are also made up of steel pipe with Van Stone flanged ends, but the flanges on these pipes are of standard weight, rolled weldless steel and the fittings are of cast iron. Bent pipes are used wherever possible to minimize joints and fittings and so as to afford ample provision for expansion and contraction without the use of expansion joints.

Drips from the muffler tank, grease-extractor tank and the exhaust piping in general which contain oil are lead to and collected in the low-pressure drip tank, from which they are pumped into the sewer. All high-pressure drips and other drips which do not contain oil are discharged into the receiving tank and utilized for boiler feed.

All piping, as well as the steam-distributing drums, tanks and other hot appurtenances are covered with mag-

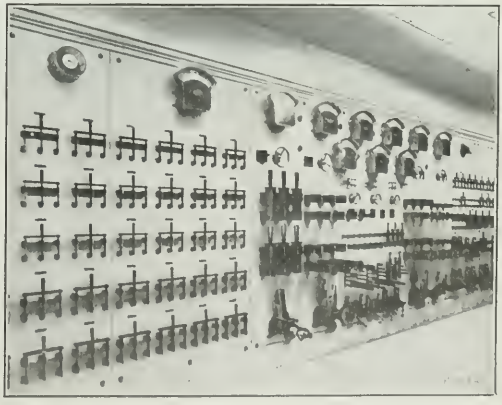


Fig. 6. Main Switchboard in Engine Room

nesia. The covering on the distributing drums, the power piping and the exhaust piping is of double thickness.

Electrical Installation

The number and capacity of the generators was given in a previous paragraph. The building is wired on the three-wire, 125-250-volt system, and two-wire generators

with balancer sets are installed. The total installed load in lamps is approximately 400 to 500 kw., and the total installed load in power is approximately 1400 kw., including the electric elevators.

Perhaps the most interesting thing about the wiring is the vertical length of some of the feeders supplying the upper floors. The longest feeder runs from the switchboard to a panel at the fifty-seventh floor, a total distance of 1000 ft., having a vertical rise of 740 ft. The strain on the vertical section of these feeders is relieved by means of clamps located about 10 ft. apart. The total number of outlets installed in the building is approximately 12,000, and the sizes of lamps vary from 25 to 60 watts.

Elevator Equipment

There is a total of 28 elevators installed in the building, and one sidewalk lift. The main group consists of 24 elevators, two of which run from the ground to the fifty-first floor; two to the forty-sixth floor and two to the forty-first floor. Four elevators run from the ground to the twelfth floor, and the 14 remaining elevators in the main group run from the basement to the twenty-seventh floor. Two additional elevators, at the rear of the building, serve for freight and employees, as well as for the occupants of the building, these two elevators running from the basement to the twenty-eighth floor. In addition, a shuttle elevator is provided to run to the observation gallery from the fifty-first to the fifty-fourth floor. An elevator is also provided to run from the bank at the second floor to the bank vaults in the basement. The two cars running from the ground to the fifty-first floor have a rise of 680 ft., and these elevators are the highest rise elevators in the world. While it is true that elevator service is provided in the Eiffel Tower, to a height of nearly 1000 ft., it is necessary to use three elevators to reach the top, the highest rise of a single elevator being approximately 450 ft.

The express elevators in the Woolworth Building run at a speed of 700 ft. per min., and are capable of lifting 3000 lb. at that speed. All of the elevators (with the exception of the shuttle and bank elevators) are of the Otis gearless electric-traction type.

In this brief description mention can be made of only some of the more important safety devices which have been provided. These are the under car safety operated by a governor placed overhead, oil buffers placed under each car, a retarding and latching device at the top of each hatchway, limit switches at the bottom and top of travel, a speed governor and potential switches operated by a governor, a switch attached to the safety plank on the under car safety, and an emergency wheel and safety switch inside of the car itself. In addition to this the traction type of elevator has the great inherent safety feature, due to the fact that if either car or counterweight overtravels, the tractive force is lost, owing to the weight of the car or counterweight being removed from the hoisting cables. Furthermore, there are a great number of electrical safety features, which form a part of the controlling equipment which safeguard the operation of the cars. For example, if the current fails for any reason whatever, a switch is opened and the brake instantly applied. Bypass resistance is also cut into the armature circuit under certain conditions which also tends to bring the car to rest.

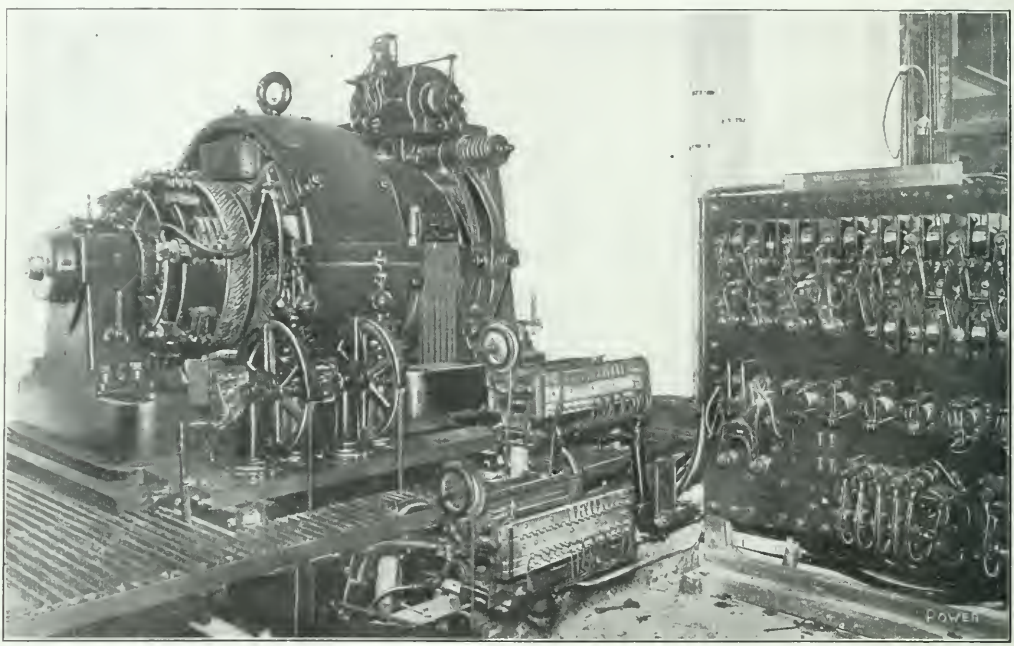


Fig. 7. One of the Traction Elevator Motors and the Control Equipment

In addition to all of the safety devices just mentioned, air cushions have been provided for all of the elevators in the building. They consist of a heavy steel structure, inclosing each elevator hatchway separately, with reinforced concrete placed between the I-beams. In addition the inner side of the shaft is lined with heavy sheet metal. As the car approaches the bottom of the travel and enters the zone of the air cushions, the air pressure underneath the car is increased, and this will be slightly noticed when riding in the car. Of course, the theory is that if all the other safety devices should fail and the car fall, the air would be so rapidly compressed, it would not have time to escape through the automatic valves or the clearance space around the car, and the speed of the car would be retarded.

An elevator dispatcher's system has been devised which will be used in the building for the first time. Briefly, the system consists of a dispatcher's station, located on the mezzanine floor, just above but in view of the main group of elevators on the ground floor, and the sole duty of the dispatcher is to start the cars and to make them conform to a given schedule as nearly as possible. For this purpose the station is provided with a lamp annunciator, which shows instantaneously the position of each car, and a telephone switchboard which enables him to communicate with each of the operators, and also a push button which rings a bell or buzzer in the car.

Heating

The entire building is heated by direct radiation, with steam at low pressure, circulating through a two-pipe system, of which the return lines are under a slight vacuum, commonly known as a return-line vacuum system. Approximately 104,000 sq.ft. of radiating surface is installed, which surface is divided into 2990 units. The radiators are of the American Radiator Co.'s manufacture and are equipped with Dunham valves.

Exhaust steam from the electric-generating plant, pumps and other steam-driven appurtenances is utilized for heating and supplemented with live steam reduced to proper pressure when necessary. The main exhaust line leading to the heating system is 22 in. in diameter up to the point where the branch is taken off for connection with the feed-water heater. At this point the exhaust main is reduced to 20 in. diameter, which size is carried up to the pipe gallery between the twenty-sixth and twenty-seventh stories, where an 18-in. branch is taken off. This branch or main is run around the pipe gallery and connected with risers feeding downward to all the radiators on the lower floors, and with all risers feeding upward to the radiators on the twenty-seventh, twenty-eighth and twenty-ninth floors. The vertical line above this pipe gallery is reduced to 18 in. in diameter and run up to a second pipe gallery located between the forty-first and forty-second stories, where a 10-in. branch is taken off, supplying risers feeding downward to the thirtieth story and upward to the top of the building.

The return lines corresponding to the distributing system in the upper pipe gallery are connected into two mains, one run in the upper and the other in the lower pipe gallery, from which levels they are run down to the sub-basement. The return lines corresponding to the risers for the lower distributing system are all run down from the twenty-ninth floor to the sub-basement, where they are connected into one main return. This main and the mains from the upper stories are all connected with the vacuum return pumps after being passed through dirt catchers.

Automatic temperature control is provided for all radiators in the public rooms in the basement and the banking rooms on the second and third floors. All other radiators are controlled by hand.

Ventilating Apparatus

A total of approximately 170,000 cu.ft. of fresh air per minute is supplied by mechanical means to the sub-basement, basement and the banking rooms on the second

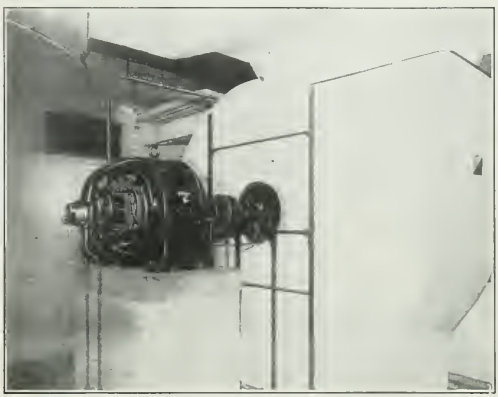


Fig. 8. Typical Fan and Motor Installation for Ventilation

and third floors, and approximately 182,000 cu.ft. of air per minute is exhausted. In addition to this about 29,000 cu.ft. per min. is exhausted from kitchen hoods, about 28,000 cu.ft. per min. from toilets in the upper stories and about 8000 cu.ft. per min. from the room on the forty-sixth floor in which the condenser tank for the free exhaust is located.

All the air-supply fans, seven in number, and the exhaust fans serving the engine room, the boiler room, the banking-room space and the kitchens (six in all), are Massachusetts centrifugal fans, with the exception of two, which are of the Howard & Morse disk type. The fans are driven by direct-connected slow-speed C. & C. motors provided with field-control regulating devices allowing a speed variation ranging from one-half to full speed.

The air supply for the machinery spaces is delivered at external temperature after being passed through cheesecloth filters, but that for the banking rooms, restaurants, swimming pool and other public rooms is passed through air washers and tempering coils where the required temperature conditions are automatically maintained.

The architect of the building was Cass Gilbert, with L. E. Eden acting as advisory engineer; Charles E. Knox was the consulting electrical engineer; the steam power, heating and ventilating equipment was installed by the Thompson-Starrett Co. under the direction and from plans and specifications prepared by Messrs. Nygren, Tenney & Ohmes, consulting engineers. For the data contained in the article the author is largely indebted to Messrs. Nygren and Knox.

A Unique Temporary Flue

By Charles H. Bromley

SYNOPSIS—Four more large boilers are installed back to back with eight already in operation. A larger flue is needed but structural conditions do not allow of putting in an overhead temporary flue while the larger permanent one is erected. A solution of the problem is found by using the alley in the cellar, the alley being formed by the building wall and the backs of the soot pits and leading directly to the chimney.

When plants, particularly office and public-building plants, are extensively remodeled or large additions are made to them, the problem of maintaining uninterrupted service while the changes or additions are made often becomes seemingly impossible of solution. In the plant in question this problem was extraordinary. One of the most interesting features of the work carried on was the making of a flue to serve temporarily while a new and larger flue was installed. The temporary flue could not

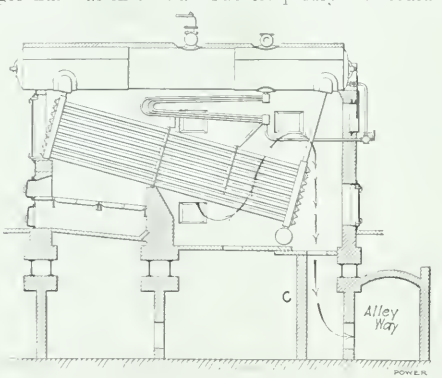


Fig. 1. Sectional Elevation Showing Soot Pits and Passage of Gases

be erected alongside or above the old one because of lack of room.

The boilers are of the B. & W. type, 250 hp., two boilers to a setting. The settings were provided with soot pits, as shown in Fig. 1, a door covering the opening being lifted so that soot from the back chamber may be dropped into the pits. These soot pits are, of course, in the cellar immediately below the boiler-room floor level. The four new boilers are of the three-drum type, 550 hp. each, one boiler to a setting. They were placed with their back chambers facing the back chambers of the eight 250-hp. boilers, with an alleyway about 5 ft. wide between. Obviously the combined boiler capacity required a much larger flue than the one serving the eight 250-hp. boilers.

As stated before, lack of room prevented building a temporary flue adjacent to the old one so that the latter could be torn out and a new and larger one installed. These soot pits *AAAA*, Fig. 2, and the building wall *B* offered a means of making a temporary flue, as the alleyway, about 4½ ft. wide and 6½ ft. high, led directly to the clean-out door of the stack, as shown. Each soot pit had a door at both ends to allow of taking out the soot and to admit air to the steam-jet blowers which produce the draft. By making the upper opening into the pit of the same area as the area of the uptake, building solid walls *C* to the right of and in line with the opening,

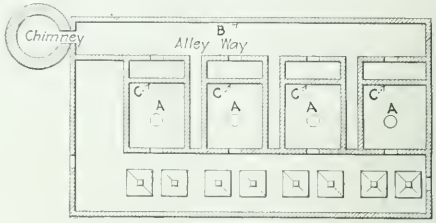


Fig. 2. Plan of Soot Pits, Ash Pits and Alleyway

also removing the clean-out door of the chimney, and closing the "back dampers," a direct and inclosed passage was made for the gases. The doorways at each end of the alleyway were, of course, closed with masonry. It was important that a tile brick or door be placed in the walls *C* to provide means for cleaning soot from the space within. As the wall is only a temporary one, it is cheapest to use a tile brick, such as is used between beams where a concrete floor is to be laid. It should be noted that the changes in no way interfered with the action of the steam-jet blowers because the front doors of the soot pits allow air to enter to supply all that necessary to produce the draft.

The only real disadvantage of such a flue is that, being on a level with the floor of the chimney, the soot cannot drop away from the point at which the gases enter the chimney. This will cause the opening into the chimney to be obstructed with soot more quickly than with the usual arrangement. It is, of course, understood that be-

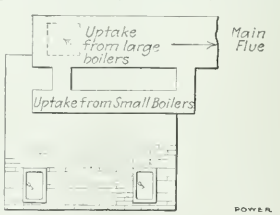


Fig. 3. Connections to Flue

fore any work was begun on the temporary flue, the soot was removed from the boilers, pits and chimney base.

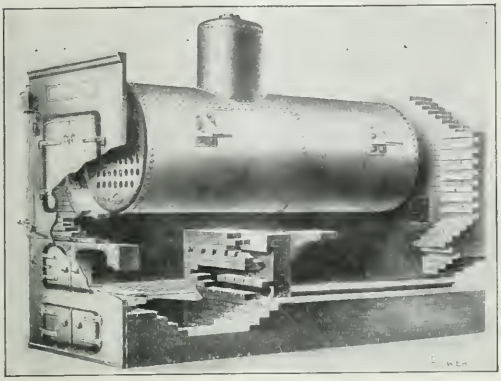
After the intake opening in the chimney had been closed off by sealing the old flue near the stack, the work of removing the old flue was begun. The new, permanent flue arrangement was made as shown in Fig. 3, which illustrates the back of a setting for two of the 250-hp. boilers.

No damper was installed in the temporary flue. This job was done at the plant of the Prudential Insurance Co., Newark, N. J.

Sullivan Smokeless Furnace

This furnace has been designed to prevent the formation of smoke and by so doing the combustion of bituminous fuel is practically complete and the boiler shell and tubes are less liable to become coated with soot.

When installing this equipment no change of furnace construction is necessary, and it can be installed under a boiler in 48 hours. The equipment is illustrated here-



Construction of Sullivan Smokeless Furnace

with, and is built by The Sullivan Smokeless Furnace Equipment Co., 90 West St., New York City.

When installed a special bridge-wall is built of firebrick and a special prepared mortar is used. The bridge-wall is made as shown. Air enters through the tube, in the case illustrated, from the rear end of the boiler setting, but this tube can come out through the side of the setting, or wherever convenient. As the escaping gases go to the boiler uptake a partial vacuum is created in the furnace which pulls in air through the air duct and through the three passes in the bridge-wall, the quantity of air entering the furnace varying with the amount of vacuum created by the chimney draft, which is greatest when fresh fuel is introduced or when the grates are covered with ash.

In the upper pass outlet holes are provided on the fire side of the bridge-wall. They are so proportioned that the same volume of air escapes through each one to the furnace, i.e., the outlet hole on the right-hand side of the upper pass, where the air pressure is the greatest, is made smallest, each succeeding hole being made a little larger than the preceding one. By this arrangement the air is evenly distributed above the burning fuel. Before the air reaches the furnace it is heated both in the air tube and in the bridge-wall passes. This heated air unites with and balances the variable air supply through the grate bars. No other agency is employed for introducing air to the furnace.

In combination with the heated air, steam is introduced through the front of the furnace just after a fresh supply of fuel has been put on the fire. The steam enters the furnace above the fire through a curved metal retort. The steam escapes through small orifices at the front of the steam retort, facing the bridge-wall, in a fine spray. The retort is embedded in the front wall above the arches, as shown, with but a width of 1¾ in. exposed to the fire. As the face does not come flush with the firebricks there is little chance of the steam holes becoming clogged.

Steam is supplied to the retort through a ½- or ¾-in. pipe connected to the steam outlet of the boiler. A special balance valve is operated by an automatic time regulator, so mounted that steam is turned into the furnace whenever the firing doors are opened. As soon as the doors are shut after firing, the valve starts to slowly close and continues to gradually throttle the steam, coincident with the reduction of excessive hydrocarbons rising from the newly fired fuel, until the steam is finally cut off. The period for closing the valve can be regulated by adjusting the time regulator. Back of the curved bridge-wall an arch is made, as shown, to assist in keeping the flames close to the boiler shell.

A Curious Smoke-Stack

The stack shown is installed at the plant of the Keokuk Water Co., Keokuk, Iowa, which furnishes the water supply to the town. Advantage has been taken of the Mississippi River bluff, to obtain a strong draft at comparatively low construction cost. The plant is at the bottom of a 150-ft. bluff, the stack leading off nearly level

A Many-Angled Smoke-Stack

until it reaches the bluff, then up a sharp angle for some distance, and then at a greatly decreased angle with the horizontal until at a distance of 300 ft. it leads into an ordinary vertical stack.

Boiler Tests on Shipboard

By H. S. Knowlton

The difference in operating conditions in steam plants ashore and afloat is well illustrated by the problems arising in each case when it is desired to carry out a service test of the apparatus. Engineers, whose practice is confined to land installations, frequently do not realize the expedients which are necessary to obtain accurate results aboard ship, or the difficulties encountered in trying to follow well known standard land methods of procedure. It is, nevertheless, possible to obtain thoroughly reliable data without following in detail the practice of engineers on land, and an illustration is afforded by a test of the boilers of a turbine-driven ship.

In this typical case the vessel was provided with 12 single-ended Scotch marine boilers placed in two rows, half on each side of a transverse bulkhead and supplied with coal from forward and aft bunkers served by buckets traveling on overhead runways. Each boiler had three furnaces and the capacity of each bucket was 500 lb. In the carrying out of the tests it was not feasible to either clean out all the fires at the start or to draw the fires, on account of the limited space in the boiler rooms and the probable delaying of the vessel. Neither was it possible to weigh all the coal as fired in the buckets or to fire directly from the latter into the furnaces.

Owing to the cramped quarters in the fire room and the rapidity with which the coal had to be passed out, no attempt was made to weigh the fuel during the trial. Each bucket supplied nine furnaces, and in firing, the coal was dumped on the floor in front of the furnaces and fired from this level. The weight of the coal used was determined by counting the number of buckets taken from the bunkers, a man whose sole duty it was to count these being stationed in each compartment of the fire room. Great care was taken to fill the bucket flush with the top, and after the test four buckets were weighed full and empty with the result that the average value agreed to a pound with previous weighing made by the company. Crude as this method appears, it gave a value for the coal agreeing within 1 per cent. with the figure obtained by the chief engineer of the company as the average coal consumption per trip, based on the runs for a whole season. Throughout the test, which lasted seven hours, 223 buckets of fuel were supplied.

The feed water was metered and tests showed that the measurements were accurate within 2 per cent. The usual requirement that feed water be weighed in tanks is impracticable on shipboard. These boilers were supplied with 3000 lb. of water per min. With the boilers placed athwart the ship it was found undesirable to attempt to ascertain the water level by the gage-glasses because of the rolling motion of the ship.

The operating engineers had found that by admitting fresh water for a certain period during each trip the level in the boilers could be made approximately the same at the beginning and end of each run. The total feed-water supply when plotted against time showed practically a straight line. The steam used by the auxiliaries was determined by calculation of the amount discharged through an orifice of fixed size.

The methods employed gave ultimate errors in the steam and fuel consumption not exceeding 3.5 per cent., the feed-water requirements being known within about 1 per cent. In this test an error in the auxiliary steam consumption of 10 per cent. could not affect the turbine steam consumption by over 1.2 per cent., and an error in the feed-water consumption would not affect the turbine steam consumption by more than 1 per cent.

The equivalent evaporation was affected by five factors: The boiler pressure, quality of the steam, temperature of the feed water, the feed-water rate and the coal rate. Any errors likely to occur in the first three items were seen to be negligible in comparison with errors in the last two, so that the error introduced in the equivalent evaporation per pound of coal did not exceed 2.5 per cent. In this case the departure from the usual methods did not interfere to any appreciable degree with the usefulness of the test, and the point may well be emphasized that it is often possible to do thoroughly good commercial work under conditions unfavorable to the accuracy of the engineering laboratory.

Improved Regan Stoking Grate

A furnace grate and mechanical stoking device that eliminates the necessity of using a slice bar and the necessary opening of the furnace doors while performing the work of slicing the fires is attracting the attention of engineers. This device, Fig. 1, permits of carrying a

Fig. 1. View of Grates at Rest

uniform thickness of fuel without opening the furnace doors for slicing and leveling the fires, and they can be practically run without cleaning because the action of the stoker keeps the fuel in a porous condition and breaks up the clinkers as they begin to form. This results in a free supply of air through the fuel bed.

The stoker consists of a series of lifting fire bars extending the length of the grate, each series spaced about 18 in. apart across the middle of the grate, Fig. 2. There are also stationary grates running across the furnace separating the stoking and chopper grates from the next series of grates. This feature is shown in

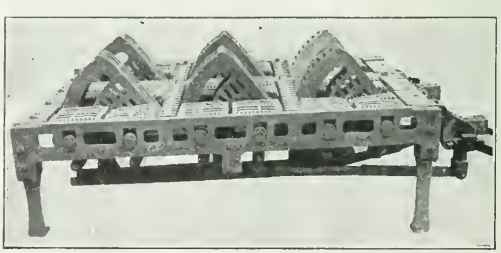


Fig. 2. As Barring Grates Look in Action

Figs. 2 and 3. The stationary bars are made with a concave surface on the sides and the stoking and chopping members are made with the convex outer ends of the same radius curve. The inner end of each chopping grate is made at a right angle to the face and the two opposing grates are so spaced that, when in their rest position, the fuel does not fall between them into the ashpit. The concave and convex surfaces of the stationary grates and the outer ends of the chopping grates are also brought so close together that sifting of fuel does not occur.

Levers for actuating the stoking grates are attached to the shaker which operates the chopper grates, but their movement is independent of the choppers, although the shaker grates may be operated in connection with them if desired. When in service the stoking device operates about as follows: All grates occupy the position shown in

FIG. 3. CHOPPER GRATES IN ACTION

Fig. 1, forming a flat surface. The fuel is hand fired in the usual manner, and then the old method of leveling and baring the fires gives way to the new. When it becomes necessary to bar the fires, as in the old method, the lever operating the stoking grates raises the end nearest the front of the furnace above the grate level. This movement lifts the burning fuel and breaks up the coal, at the same time throwing it toward the bridgewall. In Fig. 2, the stoking grates are shown operating in an opposite direction, which throws the fuel toward the front of the grate. Grates with either action may be obtained.

When the fire requires cleaning the chopper grates, Fig. 3, are operated, shaking the ash and small clinker into the ashpit. All grate sections are made extremely heavy, as shown in the illustrations.

The stoking grate is made by the Regan Grate Bar Co., 209 North Front St., Philadelphia, Penn.

An Unusual Water-Power Station

In connection with the construction work on the White Salmon River, Washington, 75 miles east of Portland, Ore., of the 20,000-hp., hydroelectric development, it was found necessary, by the Stone & Webster Engineering Corporation, to establish a temporary hydraulic plant for furnishing power for carrying on the work incident to the building of the large plant.

A power flume, 9 ft. 3 in. wide, built of wood, diverts water from the stream right through the new 125-ft. dam now in process of construction, carrying it to a point a few hundred feet below the dam where the small wooden power house has been established, the turbine operating under a 13-ft. head of water. The prime mover is a 54-in. S. Morgan Smith Co. turbine, capable of delivering a maximum of 300 hp. at this head.

This turbine is directly connected to a 150-kw., 110-volt generator. The electric power is used for various purposes on the immediate work, including quarrying on top of the hill, 400 ft. above the dam, operating concrete mixers, lighting, drilling, etc. It is also used at a point more than a mile down the river where the power house is being built, to which point it is transmitted at 6600 volts.

The depth of water in the flume is kept at 6 ft. by an ingenious arrangement of gates, such that when the water falls below 6 ft. a bypass is closed and the flow is built up; when the water tends to exceed 6 ft. the bypass is opened wide and the excess water turned into the bed of the stream between the big dam and the temporary power house.

This development, which is to be operated by the Northwestern Electric Co. of Portland, will have a head of 175 ft. and an impounded volume of 40,000,000 cu.ft. of water (1,250,000 tons). This water is gathered from a drainage area of 350 sq.mi. and is held back by a concrete dam of the solid gravity type, 470 ft. long with a 250-ft. spillway, measuring 125 ft. in height. Water will be carried from the dam to the power house by a wood-stave pipe 5100 ft. long and 13 ft. 6 in. in diameter, emptying into a concrete forebay. From this point two pressure pipes 700 ft. long and 9 ft. in diameter will give an operating head of 175 ft. The purpose of the development is for lighting and power in Portland and vicinity.

Deterioration of Steel Stacks

Of eleven companies using steel stacks, three have noticed no deterioration, says the Prime Movers Committee of the N. E. L. A. With one of these companies the stacks are lined, with another company unlined, and the third did not say whether the stacks are lined or not. All the other companies report serious corrosion of the steel. They all have unlined stacks except one company, which in lining the stack had left an air space between the brick and the metal, and in this case the corrosion was so serious in a short time that the lining was taken out, the metal scraped, and the lining rebuilt with grouting between the brick and the steel.

All of the unlined stacks reported on are apparently corroding very seriously, and almost entirely on the inside, the corrosion appearing to be worse on the upper rings. This is attributed to the moisture in the flue gases, which is condensed against the cold metal of the stack and, carrying with it a trace of sulphurous acid from the fuel, attacks the metal. As a stack is never scraped or painted on the inside, regardless of the amount of care which may be bestowed upon it on the outside, the corrosion goes on rapidly and uninterrupted, and stacks which are well cared for and frequently painted on the outside, presenting a good external appearance, are in a few years found to be in a dangerous condition, due to internal corrosion.

A simple and effective remedy for this condition is to line the stacks from bottom to top, taking care that the job is thoroughly grouted as it goes up, so that every part of the metal will be protected with cement. Stacks of this construction at the Harrison St. station of the Commonwealth Edison Co. have been standing for 20 years, much of the time in service. They have been painted every two years and are now apparently in as good condition as when first built.

ELECTRICAL DEPARTMENT

Hydro-Electric Systems*

Waterwheels

A rapid evolution has taken place in the design of waterwheels, the most marked being the increased application of single-runner, vertical-shaft turbines to low heads, where previously multi-runner turbines of either the horizontal or vertical type were used.

In low-head installations the single-runner turbine has a number of advantages over the multiple-runner. Only one gate-operating mechanism is required and this is located above the head cover of the turbine and is thus accessible at all times for inspection, while repairs can readily be made without dismantling the wheel. A better design of the draft tube is also made possible with a single-runner unit, and it is possible to mold in the concrete a spiral turbine casing similar in design to the cast-iron spiral casings used with high-head turbines.

Tests of two 6000-hp. vertical single-runner turbines, having concrete spiral casings and ideal draft tubes recently showed an average maximum efficiency of 93.7 per cent.

Generators

Generators should have a rating corresponding to the point of maximum efficiency of the waterwheel, as the efficiency of the latter, especially for low heads, falls off rapidly above and below this point. It is, therefore, desirable to operate the wheels near their maximum output, leaving only a small margin for regulating purposes, and the generator should preferably be given a maximum or continuous rating corresponding with the waterwheel.

While both 60- and 25-cycle generators are being installed as conditions determine, the increase in the size of the individual units has made it desirable to wind a large number of these for 11,000 and 13,000 volts. Very satisfactory results are being obtained by grading the insulation, and the slight corona effects noticeable on some coils at high altitudes is now readily taken care of by proper design of the insulation.

A general agreement has been reached to consider the maximum runaway speeds of waterwheel-driven units at 100 per cent. increase.

Three-phase generators should always have their armature windings connected in star. Whether the generator neutral should be grounded or not depends on conditions.

Exciters

The capacity of the exciters should be sufficient to excite all the synchronous apparatus in the station when these machines are operating at their maximum load and at the true operating power factor.

A 125-volt excitation pressure has been considered standard for moderate-size installations, while for larger plants a 250-volt exciter system will generally be found more economical. Almost all exciters are now of the direct-connected type. They may be driven either by the main generators, by separate waterwheels or by motors. The system most favored from an operating viewpoint is one in which excitation is obtained from a common source consisting of as few exciters as possible. Three units are generally provided, two for normal operation and the third held in reserve. A difference of opinion exists as to whether the two exciters used for normal operation should be waterwheel driven and the reserve unit motor driven, or *vice versa*. It seems, however, preferable to have the former motor driven; the waterwheel-driven exciters should then be used only when starting up or as a reserve.

In some of the latest hydro-electric developments a new system of excitation is being used, in that one small motor-driven exciter set is provided for each generator unit. The exciter has a capacity corresponding to its generator and the terminals are connected directly to the generator field. The motors of the various exciter sets are fed from one or two low-voltage generators driven by independent waterwheels, but in addition, the connections are so arranged that if necessary the motors may be connected to the main busbar through transformers, two separate sources thus being provided. With this arrangement the objection to motor-driven exciters on the ground that they are likely to fall out of step when a short-circuit occurs on the system, has no bearing.

Transformers

The number and size of the transformers and whether they should be of single- or three-phase type, depends entirely on the conditions to be met. With moderate voltage it has been the general practice to install one transformer bank for each generator. With a large number of units it was more advantageous to install three-phase transformers, while in plants consisting of one or two generating units where the cost of a spare three-phase transformer was not warranted, it was preferable to install single-phase units.

With present modern high-voltage systems where it is undesirable to parallel the transmission lines on the high-tension side, it has become general practice to install the transformers in groups, each having a capacity corresponding to a line. The transformers may be connected either in delta or in Y, but it is now generally conceded that the isolated delta connection is preferred, because of increased reliability. Under normal operation the voltage stress is the same whether the isolated delta or the grounded Y-connection is used, but in case of a ground on one line wire, the isolated delta system will be exposed to a higher voltage above ground than would be the case with the grounded Y-system. The disadvantage of the grounded Y-system, however, is that any ground of the line wires will cause a short-circuit and thus a shutdown, which is not the case with the delta.

The transformers should always be provided with taps.

*Excerpts from the report of the committee on the "Operation of Water Power Systems" of the National Electric Light Association.

In many instances it is desirable to begin the operation of the system at half the ultimate voltage and to accomplish this the transformers are provided with 50 per cent. taps in the high-voltage winding. It is also customary to provide the high-voltage windings with four 2½ per cent. taps below the normal operating voltage so that these can be used in compensating for the line drop as the load increases.

Power-Limiting Reactances

Increase in the size of modern generating units and the concentration of enormous power in single generating stations or systems have made it necessary not only to increase the inherent reactance of the apparatus but also to provide artificial reactances for limiting the amount of current that may flow from any part of the system into a short-circuit in apparatus or connections. By so limiting the abnormal flow of current into a short-circuit the generating system, as a whole, is relieved from possible disastrous effects.

Power-limiting reactances may be divided into three classes—generator, busbar sectionalizing and feeder reactances. The first is not used to any great extent in connection with waterwheel-driven generators, as these have, as a rule, sufficiently high inherent reactance. Busbar sectionalizing reactances are, however, becoming generally used in large stations. When a busbar becomes so large that it becomes desirable to divide it into several sections, reactances may be placed between the sections permitting any section to draw only part of its load from the adjacent sections and thus limiting the short-circuit current of one section.

Regulators and Synchronous Condensers

Regulation of large high-voltage systems involves difficulties not encountered in low-voltage work. In the latter case the energy loss is generally the limiting factor and the regulation can often be improved by installing larger conductors, which at the same time reduce the line loss. With high-voltage systems the gain from doing so is very slight, and other means must be employed for keeping the regulation within commercial limits. The effect of the inductance and capacity of the line causes the voltage to vary within very wide limits from full to no load. At no load the large capacity current causes a rise of voltage from the generating station to the receiving end, while at full load the lagging inductive current taken by the load, in general, more than offsets the effect of the capacity current and causes a drop of voltage from the generating station to the receiving end. It is evident then that by installing a synchronous condenser at the receiving end, and taking advantage of the characteristics of this machine, the receiving voltage can be kept constant by adjusting the synchronous condenser field and causing the condenser to draw a lagging current from the line at no load and a leading current at full load. The generating voltage should preferably be kept constant by means of automatic T. A. regulators. Automatic regulation of the condenser field current can also readily be accomplished by means of a T. A. regulator.

As the excitation must at times be practically zero, a special exciter arrangement must be employed to provide for the limiting voltage range of the regulator. This is accomplished by exciting the condenser from a 250-volt exciter, whose fields in turn are separately excited from a 125-volt source, consisting of two small exciters which are running opposed in series. One of these exciters is designed for 125 volts and the other for 250 volts, the regulator being placed across the 250-volt exciter. In this manner the range of the regulator is from 125 to 250 volts, never reaching zero, while the excitation of the condenser is from zero to 250 volts.

Systems of Connections

The generators should preferably be in parallel on a common low-tension busbar the generator switches being nonautomatic, or if automatic protection is desirable the switches should be provided with definite time-limit relays, set very high. Reverse-power relays are also occasionally installed, but are generally arranged to ring an alarm gong in case of reversal of the power, and will not trip out the switch.

It is customary to provide nonautomatic oil switches in the outgoing and incoming lines to be used in case of sectionalizing and in addition nonautomatic tie switches should also be provided between the lines, or if more than two lines are present it may be advisable to provide high-tension transfer busbars. Sectionalizing switches of the knife-switch type should be installed at certain intervals on the towers along the line, so that the circuits may be sectionalized in two or more sections to facilitate testing and for isolating line troubles.

With this system of connections considerable responsibility is placed on the operators, as the relays of the transformer switches must be set at from 100 to 150 per cent. overload, or above the safe continuous operation of the transformers. Assume, for example, a system with two parallel lines connected to two transformer groups on the unit principle. A trouble in one of the lines will then cause it to be disconnected together with the transformers through which it is fed. This then throws all the load over to the remaining line, which, with its transformers, will be overloaded 100 per cent., and in order that this line shall not be disconnected at this increase in the load, the relays must be set for more than 100 per cent. overload. Transformers can, however, carry 100 per cent. overload for five or ten minutes, which should give the operator sufficient time to sectionalize the defective line and connect the transformers in parallel to feed the remaining line.

Lightning Arresters

Aluminum-cell electrolytic lightning arresters are now used almost entirely for lightning protection of high-voltage transmission systems. This type has an enormous discharge capacity, and its general characteristics are well known. The arrester, however, is not a universal protector against all kinds of interruptions. For example, while it meets the usual needs in protection against disruptive potentials from lightning, an arrester located in the station cannot protect an insulator out on the line from a lightning flash. Neither is it designed to protect against surges of relatively low potential.

The comparatively recent addition of a charging resistance will insure a material improvement in the operation of the arrester, as well as increased life of cones and electrolyte. The charging current is limited, and its wave form is so modified that, even with such a delicate test as a parallel telephone circuit, it is impossible to

detect any action of the charging of resonant parts of the circuit.

Handling the Load

Most modern systems of any size have a method of operation which corresponds to that of a train dispatcher on steam railroads, and where many different plants are attached to the same network this becomes practically necessary. The directions for operating the different stations and apparatus come from a central source, where the chief operator has before him a diagram of the system and information regarding the capacities of the generators in use and of the magnitudes of the loads at the different places of distribution.

In the larger hydro-electric systems there are usually some plants which have storage, and others which do not, so that a distinction in operating these is well made by having the storage plants do the regulating for the system. The switching operations are determined by the general method of operation.

When a line is to be cut into service, the high-tension switches in both the main and substations should be closed first, then the low-tension transformer switch in the generating station should be closed, energizing the transformers and the line, after which the low-tension transformer switch in the substation is closed and the load picked up. In case it becomes necessary to open a high-tension switch in a loaded line, the circuit should, if possible, first be paralleled with another before opening the switch. If, on the other hand, transformers are to be paralleled on both high- and low-tension sides, the low-tension switch should be closed first, assuming that the low-tension busbar is energized. Similarly, in cutting out the transformer the low-tension switch is opened last.

Voltage on Short-Circuit

A correspondent asks, "Why does an inductor alternator generate no voltage on short-circuit?"

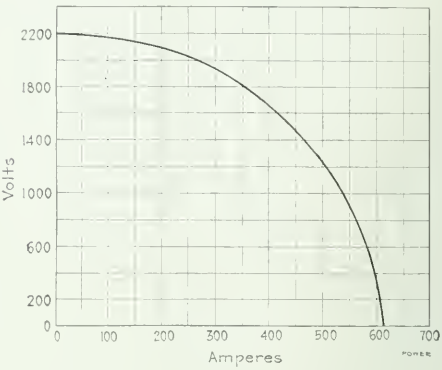
In discussing the cause of the no-voltage condition upon short-circuit, consider the curve which shows the variations of terminal voltage with simultaneous changes of load current, the speed and the resistance in the field circuit remaining constant.

In general, this curve for alternators will be of the approximate form shown, with a gradual slope toward the horizontal axis. The drop in voltage is due to the resistance, self-induction and reactions of the armature. As the load is increased, the I^2R loss is raised together with the e.m.f. of self-induction. The latter is expressed by the formula $E = 2\pi fLI$, where f is the frequency, L the coefficient of self-induction for the armature and I the current. It is evident that as the loads become heavier, the e.m.f. of self-induction is correspondingly increased. This pressure is opposed to the flow of the current and to the voltage producing it; hence as the self-induction increases, the terminal voltage diminishes.

The armature reactions, increasing with the external current, also have a lowering effect upon the machine voltage by opposing and distorting the field flux.

The form of the external characteristic depends upon the design of the machine. For alternators whose armatures contain a large amount of self-induction, the curve will cross the horizontal axis at lower current values than with machines of the same capacity whose armatures do not contain as much self-induction. The armature reactions also have a pronounced effect on the curve.

The zero voltage reading on short-circuit, of the generator in question, is not necessarily due to the fact that the machine is of the inductor type, inasmuch as the general principles governing the operation of these machines are practically the same as for the movable-coil



Variation of Voltage with Current

types. The main distinguishing feature of the inductor class is that both its field and armature coils are stationary, the alternations of field flux being produced by laminated iron projections, or inductors, which are carried on a revolving spider. There are many designs and makes of this type; hence the armature circuits of some will contain more inductance than those of others. In this case, the e.m.f. of self-induction together with the I^2R drop and armature reactions undoubtedly became so great upon short-circuit that the terminal voltage was reduced to zero, but this might have happened under similar conditions with an alternator of the movable-coil type.

Loss of Voltage

Among the "Inquiries of General Interest" in the May 20 issue was one with the heading, "Loss of Voltage." While friction between the brushes and the commutator might account for some loss in voltage yet it would hardly seem possible that all of the drop was on that account. As without load and with all resistance out of the field rheostat the voltage was only 300 volts and as that is 50 volts more than the rated pressure for the machine it would not be surprising if, at full load, the voltage should drop down to normal. Another point which might indicate that the drop was caused both by the reaction in the armature caused by the heavy load and also by the increased resistance of the shunt field, due to its heating when under heavy load, is that the rating of the generator is evidently wrongly given at the beginning of the question. There the load is given as 250 volts and 80 amperes, but the capacity is said to be 33 kw. Could it not be that the operator has made a mistake and the machine is carrying more load than it was designed for?

This would cut down the voltage and would seem to be borne out by the fact that the dynamo gets very warm.

Brooklyn, N. Y. G. H. McKelway.

GAS POWER DEPARTMENT

Heat Balance of a Producer*

By Julian C. Smallwood

The heat of coal consumed by a producer is distributed in four parts: First, the useful heat, appearing as the calorific value of the dry, cool gas; second, the heat carried by the gas as sensible heat and as latent heat of the excess steam; third, the heat lost to good fuel removed with ash; fourth, the heat lost through deposits of tar and soot, absorption or leakage of gases, and radiation from the producer.

The selection of methods of measuring these heat quantities is governed somewhat by the type of producer and the fuel. In any case, it is necessary to measure the coal and ash during a test of sufficient duration, and to provide a proximate analysis of the coal and a chemist's analysis of an average gas sample. The gas usually contains between 10 and 20 per cent. of hydrogen, 1 to 3 per cent. of marsh gas, and a small amount of olefiant gas, in addition to CO_2, CO and N_2.

The calorific values of both coal and gas may be calculated from their analyses.

The volume of gas generated may be figured from the gas analysis with acceptable accuracy in most cases. This calculation depends upon the assumption that all the carbon gasified appears in the gas analysis. It is, therefore, approximate since the condensible hydrocarbons distilled from the coal throw down some carbon in the form of tar, and some disappears as soot. In the case of anthracite gas, or well fixed bituminous, this is almost negligible.

The largest error likely to occur is in the measurement of the coal; hence the conditions at starting and stopping should be noted and made in all respects nearly the same as is possible. Starting and stopping should be timed just after a regular cleaning. The duration of the test should be long enough to reduce the probable error caused by the variation in fuel content of the producer to a small percentage of the total coal fired; this, in general, will not be less than 12 hr. Uniform coal consumption, as well as uniform external conditions, must be maintained as constant as possible and the producer should be run for some hours under the required conditions before starting the test.

The ash and refuse should be collected at regular cleaning intervals and weighed after drying. It is best to secure a sample of the total refuse just before weighing and to determine its moisture and carbon as in the proximate analysis of the coal. It is often awkward to dry all the refuse thoroughly, but, if the percentage of moisture is known, the weight of dry refuse may be readily figured.

Sampling of the coal and ash should be done as for a boiler test. Sampling of the gas should be as described in the article on "The Heat Balance of a Gas Engine," appearing in the Apr. 1 issue. The gas should be collected before entering the scrubber, and after leaving it if it is desired to find the effect of absorption or leakage.

The weight of steam furnished to the suction producer, exclusive of that due to vapor in the air and moisture in the coal, may be found by supplying the vaporizer with water from a calibrated vessel and collecting and weighing the overflow. For a pressure producer, an orifice or nozzle method may be used to meter the steam, or it may be measured by weighing the feed water evaporated by the auxiliary boiler.

The calculations from the test of an anthracite suction-producer plant will first be given, and then the modifications necessary for other types. Tables 1 and 2 give the required test data together with the notation used in the

TABLE 1. DATA FROM A SUCTION-GAS PRODUCER TEST AND NOTATION USED IN FORMULAS

	Total weight of coal charged, lb.	= 798
	Total weight of ash and refuse, lb.	= 85
	Total weight of water used in vaporizer, lb.	= 268
	Proximate analysis of the coal. Percentage by weight of the coal as fired.	
	Moisture	= 2.75
	Volatile matter	= 6.00
	Fixed carbon	= 78.45
	Ash	= 12.8
m, vm, fc	= Weights of moisture, volatile matter, and fixed carbon per pound of dry coal, respectively.	
	Weight of carbon in 1 lb. of dry refuse, pounds	= 0.388
C_t	= Total weight of carbon in 1 lb. of dry coal, lb.	
C_a	= Weight of carbon wasted in ash, per lb. dry coal, lb.	
C_g	= Weight of carbon gasified, per lb. dry coal, lb.	
c, p	= Sums of columns (3) and (5), Table 2, respectively	
V	= Volume, standard cu.ft. of dry gas generated per lb. of dry coal	
Wp	= Weight of the producer gas per lb. of dry coal, lb.	
Wa	= Weight of the air furnished per lb. of dry coal, lb.	
Ws	= Weight of steam furnished per lb. of dry coal, from the vaporizer, lb.	
ws	= Weight of steam not dissociated per lb. of dry coal, lb.	
Tp	= Temperature of gas leaving producer, deg. F.	= 1108
t	= Temperature of fire room, deg. F.	= 82

formulas. The data are part of the full observations of a test reported in the *Journal* of the A. S. M. E., December, 1909, for which the ultimate as well as the proximate coal analyses and calorimetric determinations of fuel and gas were made, and the gas metered. The reader may thus compare the results by the approximate formulas to be presented with the more exact results of the report.†

All the items of the heat balance will be figured on the basis of one pound of dry coal. The calorific value of the dry coal will thus be the heat supplied, if the sensible heat carried in by water, air, etc., is neglected.

Preliminary Calculations

The proximate analysis is generally expressed in percentage by weight of the coal, including moisture. To find the weights per pound of dry coal, it is necessary only to divide each of the items by 100 minus the percentage of moisture as reported. Thus,

$m = 2.75 \div (100 - 2.75) = 0.0283$ lb. of moisture;

$vm = 0.0617$ lb. of volatile matter;

$fc = 0.807$ lb. of fixed carbon;

$a = 0.132$ lb. of ash;

$vm + fc = 0.869$ lb. of combustible.

*Copyrighted, 1913, by Julian C. Smallwood, Associate Professor of Experimental Engineering, Syracuse University.

†Note that these results are given for the standard gas condition of 62 deg. F. and 30 in. of mercury, whereas the standard here used is for 32 deg. F. and 29.92 in. The volume per pound of the latter is 0.943 times that of the former. Also the specific heats of the gases are different, the values in this article being according to later authorities.

It is necessary to make an estimate of the total carbon in the coal, since the proximate analysis gives no value of the carbon contained in the volatile matter. This may be done according to the method suggested by Professor Marks (POWER, Jan. 14, 1913) for semi-anthracite and bituminous coals. For anthracite coals in these calculations sufficient accuracy is attained by taking the volatile carbon as 1 to 2 per cent. of the combustible when the volatile matter is from 5 to 10 per cent. Then, with the given data, the total weight of carbon in one pound of dry coal is

$$C_t = 0.807 + 0.01 \times 0.869 = 0.816 \ lb.$$

The total carbon in the ash equals total dry refuse (ash + carbon) minus ash in 1 lb. coal times total coal as fired. It is uncertain, however, that all the ash from the coal consumed during the test is taken from the producer, so that it is better to analyze a sample of the refuse, for the amount of carbon in the refuse per pound of dry coal consumed is

$$C_a = \frac{Weight\ of\ dry\ refuse \times weight\ of\ C\ in\ 1\ lb.\ of\ refuse}{Total\ weight\ of\ dry\ coal}$$

In the test under consideration, each pound of the refuse was found to contain 0.388 lb. of carbon. The total coal as fired was 798 lb. Subtracting from this the moisture, which equals 0.0275×798, or 22 lb., the weight of the dry coal is 776 lb.; from which

$$C_a = \frac{85 \times 0.388}{776} = 0.042 \ lb.$$

The carbon gasified is all of the carbon in the coal except that removed with the ash. Hence

$$C_g = C_t - C_a$$

for the given data, $C_g = 0.816 - 0.042 = 0.774$ lb. of carbon per lb. of dry coal.

The volume of dry gas generated per pound of dry coal should be calculated for a standard condition of pressure and temperature. The standard here used corresponds to 29.92 in. of mercury and 32 deg. F. Then

$$V = \frac{2980 \times C_g}{c}$$

the value c being found as shown in column (3) of Table 2, and the value $\frac{2980}{c}$ being the cubic feet of producer gas per pound of carbon in it. For the given data

$$V = \frac{2980 \times 0.774}{33} = 69.9 \ cu.ft.\ per\ lb.\ dry\ coal$$

The weight of the dry gas per pound of dry coal may be obtained from this if the weight of a cubic foot of the gas is known.

$$Weight\ per\ cubic\ foot = 0.000028 \times p$$

the value p being found as shown in column (5) of Table 2. For the given data,

$$Weight\ per\ cubic\ foot = 0.000028 \times 2576 = 0.0721 \ lb.$$

From which, the weight of the producer gas per pound of dry coal is

$$W_p = 0.0721 \times 69.9 = 5.04 \ lb.$$

The weight of air Wa supplied to the producer per pound of dry coal is given by the formula

$$W_a = \frac{3.04 \times N_2 \times C_g}{c}$$

N_2 being the per cent. by volume of nitrogen in the gas as given in column (2), Table 2. For the given data,

$$W_a = \frac{3.04 \times 56.4 \times 0.774}{33} = 4.02 \ lb.$$

The weight of steam, W_s, supplied by the vaporizer per pound of dry coal is found by dividing the total weight of water to the vaporizer by the total weight of dry coal. For the given data,

$$W_s = \frac{268}{776} = 0.345 \ lb.$$

Coming now to the heat balance, the first item is

(a) *Useful heat in the cool gas.* This is exclusive of sensible heat if the gas is to be used for power, and is due to its calorific value when completely burned. The higher heat value will be used. Since all items of the heat balance are based on one pound of coal, the useful heat may be found by multiplying the volume of gas, per pound of coal, V, by the higher heat value in B.t.u. per standard cubic foot. The heat value may be figured as in column (7) of Table 2. This gives the values for the gas constituents, according to their amounts in one cubic foot, the sum of which is the required heat value. For the given data, the useful heat is $69.9 \times 148 = 10{,}300$ B.t.u.

The heat value of the dry coal was found to be 13,040

TABLE 2. ANALYSIS OF GAS GENERATED DURING TEST, AND COMPUTATION OF QUANTITIES USED IN FIGURING RESULTS

(1) Constituents of gas	(2) Percentage by volume	(3) Subscript of C x (2)	(4) Molecular wt. of (1)	(5) (2)x(4)	(6) Higher heat value of (1)	(7) (6)x(2) / 100
CO	27.0	27.0	28	756	342	92.4
H_2	10.4	—	2	20.8	348	36.2
CH_4	1.8	1.8	16	28.8	1065	19.2
C_2H_4	0.0	0	28	0	1680	0
O_2	0.2	—	32	6.4		
CO_2	4.2	4.2	44	184.8		
N_2	56.4	—	28	1579.2		
		c = 33.0		p = 2576.0		147.8 = higher heat value of gas

B.t.u., hence the "cold gas" efficiency of the producer is $10{,}300 \div 13{,}040 = 79$ per cent.

(b) *Sensible heat in the dry gas leaving the producer* equals

$$W_p \times specific\ heat \times (T_p - t)$$

The weight of the dry gas has been previously figured.

The specific heat of producer gas varies greatly with the hydrogen content. Except for hydrogen the average specific heat of all the gases, exclusive of steam, may be taken as 0.26 for a temperature of 1100 or 1200 deg. F. The specific heat of hydrogen for these temperatures is about 3.72, so that even though its percentage by weight is always small, the effect of hydrogen upon the average specific heat of producer gas is very marked and varies with the amount of hydrogen present. The accompanying curve gives the average specific heats of normal producer gas with various percentages of hydrogen. For the given data ($H_2 = 10.4$) it is seen to be 0.288.

The temperature of the gas should be taken near the outlet at the producer with a suitable pyrometer. For the given data,

$$Sensible\ heat = 5.04 \times 0.288 \times (1108 - 82) = 1490 \ B.t.u.$$

or

$$1490 \div 13{,}040 = 11.4 \ per\ cent.$$

(c) *Heat lost by excess of steam to the producer.* This is estimated from the weight of steam found in the gas per pound of dry coal, and equals

$$w_s \times total\ heat\ per\ pound\ of\ the\ steam$$

The total heat of the steam may be taken with sufficient accuracy for this calculation, as

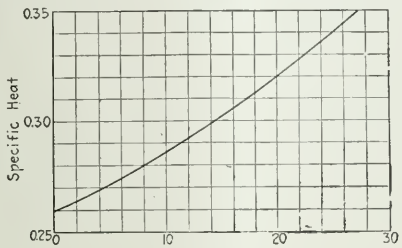
$$1000 + 0.5 \times Tp$$

For a more exact value, the expression quoted in the "Heat Balance of a Gas Engine" may be used.

To find ws several methods are open. It may be measured directly by drawing a sample of the producer gas through a tube of calcium chloride, the increase in weight giving the moisture absorbed. The gas is siphoned into a container of known size so that its volume, and, hence its weight, may be obtained. ws may also be figured from the hydrogen content of the coal and the gas. An easier method is based upon the fact that the sum of the weights of the gasified carbon, air and water vapor fed into the producer must equal the weight of the producer gas, including moisture. Hence,

$$Cg + Wa + Ws + m + \textit{vapor brought in with air} - Wp = ws$$

The air vapor may be neglected here, although it may be a large percentage of the total steam, since its latent



Variation of Specific Heat of Producer Gas with Different Percentages of Hydrogen

heat is not added by the coal. Then, for the given data,

$$ws = 0.774 + 4.02 + 0.345 + 0.0283 - 5.04 = 0.137 \textit{ lb.}$$

from which the heat lost to the steam is

$$0.137 \times (1000 + 0.5 \times 1108) = 213 \textit{ B.t.u.}$$

or

$$213 \div 13{,}040 = 1.6 \textit{ per cent.}$$

Items (b) and (c) together equal the heat given to the scrubber plus that radiated between the scrubber and producer outlets. For comparison, or to get an estimate of the amount of sensible and latent heat in the gas without measuring it as just described, the heat added to the scrubber water may be determined. The water may be measured by a meter, and its temperature rise ascertained, as for the jacket water of a gas engine. In the test quoted the total weight of scrubber water was 22,200 lb. and its temperature rise was 45.8 deg. F. Hence, the heat given to the scrubber per pound of dry coal is

$$\frac{22{,}200}{776} \times 45.8 = 1310 \textit{ B.t.u.}$$

(d) *The heat lost to carbon in the ash.* Taking the heat value of carbon as 14,500 B.t.u., this loss, per pound of dry coal, is $14{,}500 \times Ca$. For the given data,

$$14{,}500 \times 0.042 = 610 \textit{ B.t.u.}$$

or

$$610 \div 13{,}040 = 4.7 \textit{ per cent.}$$

(e) *Radiation from the producer and other losses.* These may be grouped in one item by subtracting the previously calculated heat balance quantities from the heat supplied, or some of them may be separately determined. The loss by leakage of air in the case of a suction-producer plant may be found by comparing the useful heat, as herein calculated, before and after the dilution. In a pressure-producer plant, any leakage is apt to be detected; the only way to measure it is by metering the gas since leakage does not alter its composition. The loss due to tar and soot may be found by a special analysis of the gas as it leaves the producer.

Grouping these losses for the given data, we have

$$\textit{Radiation, etc.,} = 100 - (79.0 + 11.4 + 1.6 + 4.7) = 3.3 \textit{ per cent.}$$

Other efficiencies and results. The "hot gas" efficiency is often expressed when the gas is used for heating. In this case the sensible heat is also "useful." If, then, the first three items of the heat balance in per cent. are added, the result will be the hot gas efficiency. For the given data, this is

$$79 + 11.4 + 1.6 = 92 \textit{ per cent.}$$

The "efficiency based on combustible," corresponding to the boiler efficiency so known, is the efficiency that would be obtained if there were no loss of fuel in the ash, and equals

$$\textit{Efficiency based on coal} \div \left(1 - \frac{Ca}{vm + fc}\right)$$

the quantity in the parenthesis being the efficiency of the grate, or cleaning. For the given data, this efficiency equals

$$79.0 \div \left(1 - \frac{0.042}{0.869}\right) = 82.9 \textit{ per cent}$$

for the cold gas.

For purposes of comparison of tests with different kinds of fuel, it is useful to obtain the volume of gas per pound of combustible. This equals

$$V \div (vm + fc).$$

In capacity tests, the output may be measured in cubic feet per hour by multiplying V, as herein calculated, by the weight of dry coal used per hour.

For pressure producers it is necessary to account for the coal used in the auxiliary boiler to make steam. This may be included in the total coal charged against the producer, and another item added to the heat balance to account for the heat used in the steam-making process. Or, from the volume of gas generated there may be subtracted an amount equivalent to the steam supplied, which does not seem to be so logical a process.

For bituminous producers, if much carbon disappears as tar, it is necessary either to meter the gas to get V, or to determine the amount of carbon going to tar from one pound of dry coal, by analysis of a sample extracted from a measured volume of gas. From this result it is possible to obtain a more correct value for the amount of carbon gasified.

The heat balance may be extended to cover the distribution of heat in a gas engine supplied by the producer, by the methods indicated in the article covering this subject. In this case, the gas need not be metered since the fuel quantities are measured in the coal, and the heat quantities should be based upon one pound of dry coal instead of one cubic foot of gas. The exhaust losses as calculated in the previous article may be readily changed to the coal basis by multiplying them by V as herein obtained.

REFRIGERATION DEPARTMENT

Refrigeration a Desirable Load for Central Stations*

During the last few years central-station men in all parts of the country have come to understand the marked effect that a high annual load factor has on reducing unit-output costs, and are desirous of securing those classes of business which will tend to bring up load factor. One of the important lines of business which comes under the above head is that of refrigeration. Up to comparatively recent times refrigeration has been confined to large steam-driven plants used in either the manufacture of ice or in cold-storage warehouses. The advent of the electric motor and the availability of central-station service at all hours have made possible the wide use of refrigerating apparatus, so that at the present time it becomes a part of the standard equipment of practically every class of modern building.

A more recent development of the use of central-station power in this class of business is in connection with the manufacture of ice in large quantities, and this is an important field for central-station exploitation, as it involves the use of large blocks of power during off-peak hours, and at a high annual load factor. This has already reached such proportions that last season in one city alone there was manufactured 100,000 tons of ice with central-station power.

In the last year's report of the committee it was pointed out that there are in the United States about 2000 steam-driven ice plants, which, if operated by central-station power, would mean a consumption of from 600,000,000 to 700,000,000 kw.-hr. per year. The probabilities are that there will be a steady increase in the number of ice plants.

Advantages of the Electric Plant

One of the principal advantages of the electrically operated ice plant is that it may be built at or near the center of the territory to which it is to supply ice, irrespective of railroad facilities. This is an important point, as a large item of cost in the ice business is that of delivery to the consumer. The ideal arrangement is to install plants of from 80 to 100 tons capacity about two miles apart, so that each plant will supply the territory within a radius of a mile, thus reducing delivery to a minimum. One other point of advantage is that better ice can be produced, as the trouble frequently encountered in steam-driven plants of having oil carry over from the engine cylinder is eliminated.

Ice Making

It might be well to point out a few physical facts in connection with the manufacture of ice.

Chemically-pure water free from air will freeze solid and clear.

Water containing impurities in solution tends in freezing to force these impurities out of solution. The slower the process of freezing the more completely is the purification effected.

Ice formed in still water sends out long, slender crystals, which increase in number and size, forming a meshwork which gradually becomes a solid mass.

Agitation of water during freezing aids in the separation of impurities and is, therefore, of value in the forming of solid, clear ice.

Practically all natural waters contain air and more or less organic or inorganic material in solution. These substances tend to cause the ice formed to be opaque, but as they are frozen out of solution, those that are light rise and collect near the surface, and heavier ones stay near the bottom.

The rate of ice freezing increases as the thickness already formed increases. The time required to freeze increases as the square of the thickness to be frozen. The formation of natural ice is from the top down and impurities frozen out of solution fall. This and the motion of the water, especially in quiet-running streams, tend to make natural ice transparent. American manufacturers of ice have always tried to duplicate this clearness, although in foreign countries opaque ice is frequently used commercially.

Distilled Water Ice Making

From the foregoing it will be noticed that distilled water will freeze solid and practically clear. This is doubtless one of the main reasons why such a large number of plants now in existence are making ice from distilled water. The plan was to utilize the condensed water from the engines for a large part of the distillate. It might be thought by a casual observer that this was an ideal arrangement against which purchased power could not compete. The situation has been met, however, in two ways, (1) by making raw-water ice, i.e., freezing the water without first distilling it, and, (2) in cases where distilled-water ice is desired, by securing the necessary distilled water by means of a multiple-effect evaporator. This is an efficient piece of apparatus for securing a high evaporation of water per pound of coal. With this apparatus six times as much water can be evaporated per pound of coal as with the ordinary boiler. To secure this result, advantage is taken of the fact that water will under vacuum evaporate at a much lower temperature than under ordinary conditions.

Evaporators for ice-plant work are classified broadly into two types—exhaust and high pressure. In a standard noncondensing steam-driven ice plant the losses vary from 10 to 20 per cent., and, hence, 100 tons of distilled water in the cans means at least 115 tons produced or handled. Of this amount the compressors and auxiliaries will furnish not over 90 tons; hence a makeup of 20 to 25 tons must be bled from the boilers at the average rate of evaporation of the plant. The exhaust-steam evap-

*Excerpts from report of the Committee on Refrigeration read before the National Electric Light Association, Chicago, June 2-6, 1913.

orator in single effect with an economy of eight tons of distillate per 10 tons of steam, supplies this makeup with a consequent direct saving in coal represented by this evaporation in the boiler less pump charges. With two-effect plants operating from a few pounds above atmosphere to, say, 25 in. of vacuum, the economy may be increased to a ratio of 2¼ to 1 of steam.

If the plant be put upon a standard compound-condensing basis a still greater deficiency exists, say, 60 per cent. of the total coming from the evaporators, and the cost of production is still more against central-station power. Evaporators for the service may be two or more effects, depending upon the price of coal. Their economy may run to as high as 5½ to 1.

For motor-driven ice plants the problem is to produce the distilled water as cheaply as possible, and resolves itself into a consideration of capital investment versus efficiency, and the governing factor is usually the price of fuel. With motor-driven pumps, an eight-effect plant will give an economy of 6 to 1, and, hence, produce with average Western coal and boiler performance, 45 to 48 tons of distilled water per ton of coal. It is seldom economy to exceed eight effects.

REPRESENTATIVE ICE PLANTS USING CENTRAL-STATION POWER

Plant	Rated Capacity per Day Tons	Total Connected Load Hp.	1912 Data Yearly Kw. Maximum Demand	Rated Capacity Maximum Demand per Ton, Kw.	Yearly Ice Output Tons	Annual Kw.-hr.	Average Kw.-hr. per Ton of Ice	Months of Operation
DISTILLED-WATER PLANTS (CAN PLANTS)								
Knickerbocker Ice Co., 61st St. Plant, Chicago	120	564	364	3 0	37,205	1,457,912	44.7	8
Knickerbocker Ice Co., 65th St. Plant, Chicago	90	375	248	2 7	9,005	568,824	63	5
Englewood Distilled Water Ice Co., Chicago	80	302	236	3 0	8,651	487,658	56.3	5
Webster-Citizens Co., Mechanics St. Plant, Buffalo, N. Y.	90	427	230	2 5	33,002	1,444,608	43 7	12
RAW-WATER PLANTS (CAN PLANTS)								
Lincoln Ice Co., Chicago	120	511	362	3.0	27,839	1,455,012	52 2	12
Crystal Ice Co., Chicago	60	235	233	3.9	9,656	622,186	64 5	10
RAW-WATER PLANTS (PLATE SYSTEM)								
Crystal Ice & Storage Co., Buffalo, N. Y.	130	352 5	297.4	2 3	16,243	938,100	57 7	12

Raw-Water Plants

To do away with the necessity of using distilled water, many raw-water plants have been built and are giving good results. One of the items which must have an important bearing will be the character of the water supply. In some sections of the country where the water contains a large amount of mineral substance in solution, it may be difficult to secure clear raw-water ice, but ordinarily there is very little difference in the appearance of distilled-water ice and raw-water ice as manufactured in the best plants.

The methods of manufacture of raw-water ice can be classed under two general heads—the first known as the can system and the second as the plate system. Most of the plants now in operation are of the can type, although there are a few of the plate variety.

Can Plants—In a can plant the ice is formed in large cans in which filtered raw water has been placed, these cans being immersed in tanks of refrigerated brine which is being constantly circulated by means of pumps. During the process of freezing, the water in the cans is agitated by means of compressed air to secure clear ice. The water in the cans is permitted to freeze until the core is reached, at which time the core water is replaced by distilled water and the cake frozen solid, leaving simply a feathery effect through the middle of the cake. This removal of the raw water from the core is necessary to secure a clear cake of ice, as it would be impossible to agitate the raw water until it is entirely frozen. Then, too, the water which has been removed from the core contains practically all of the impurities from the entire can. This process involves the use of between 15 and 20 per cent. of distilled water which can be supplied by means of a small multiple-effect evaporator, such as is used in regular distilled-water plants.

Plate Plants—In the plate type of plant hollow plates through which cold brine or ammonia can be made to circulate, are immersed vertically in tanks filled with water which is agitated. The ice forms gradually on both sides of the plates, thus ridding itself of any air or other impurities on its surface. In the can system these impurities concentrate toward the center, forming an impure core which is removed as previously explained. With the plate system it is not necessary to distill or boil water which is otherwise pure for ice making. The plate plant however, requires more skill to manipulate it successfully, and is more expensive to install and keep in repair.

In this system when the ice is formed to the desired thickness (usually about 12 in.), it is loosened from the freezing plates by various thawing arrangements. The ice cakes, often 9x16 ft. by 12 in. in thickness, are lifted from the tanks by overhead cranes, and are carried to a table where they are cut to commercial size.

Motor Drive

In order that the successful operation of an electrically driven ice plant may be assured, it is necessary that a proper equipment be installed. One of the important features is the type of motor to be used. In all probability the great majority of the plants to be considered will be located in territory in which the central-station supply is alternating current; in fact, all of the large plants thus far constructed have been equipped with three-phase motors. There is some difference of opinion as to whether motors should be designed for constant speed or variable speed. In any event, they should be of the slow-speed, slip-ring induction type, and equipped with drum controllers. In case constant-speed work is desired, the resistance to be furnished with the controller need be large enough simply for starting the motor. If at a later time it becomes desirable to operate the motor at variable speed, the only change required will be to install additional resistance. The use of multispeed motors has been suggested for this class of work, but it was the opinion of the committee that this practice should be discouraged, as the efficiency of the motor at full load is not quite

as high as the standard motor, and, furthermore, the power factor is considerably lower.

Voltage of Motor

While some of the companies have adhered to the standard practice of using 220-volt motors, others have adopted the plan of operating the large compressor motors at primary voltage of approximately 2300 volts, using lower voltage on motors operating the auxiliaries. The efficiencies of three-phase motors are the same at either 230 volts or 2300 volts. The factors involved in making a choice are the economies in operation due to the elimination of transformer losses, and the comparative costs of first installation. The use of primary voltage on motors, however, introduces a risk to attendants which many of the large companies hesitate to assume.

Comparative Operation—Steam and Electric

The question is often asked whether or not an electrically operated plant can be made to operate as cheaply as a steam-driven plant when the location is favorable to the steam plant, that is, when ample railroad facilities are available so that coal can be brought in under the best conditions. The question is best answered in the words of one of the largest ice operators in the country, who has a number of distilled-water ice plants, both steam and electric. He states that under his conditions of operation there is practically no difference in the cost of manufacture under the two systems. Under the electric plan of operation, however, he can locate plants to best suit his needs.

Operating data on typical electrically driven ice plants will be found in the accompanying table.

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One Cause of Decreased Output in Ice Plants

By Peter Neff

It sometimes happens in an ice-making plant which operates on what is termed the flooded system, that the capacity falls off without apparent reason. The engineer is sure the system is working perfectly, that frost shows at the feed valve, and all other conditions seem to be as usual, and yet the capacity of the plant has decreased. From my experience this trouble is most frequently the result of a very simple cause.

As is well understood, the production of the cold is brought about by the absorption of what is termed latent heat, in changing the liquid ammonia into a vapor; the heat required being taken from the medium surrounding the evaporator, thus cooling it. And, further, that if in place of liquid ammonia being introduced into the evaporator, there be uncondensed ammonia vapor, this vapor when it encounters the low temperature will condense, and in doing so will impart to the evaporator the latent heat which it contains. The evaporator will become heated, resulting in the failure of the system to produce any useful work. Such a condition would be quickly apparent to the engineer in charge.

On the other hand, if, while the plant is running continuously, the production is normal and the system in proper condition, there is supplied to the feed valve a mixture of liquid and vapor, what is the result? Suppose that for every 10 lb. of ammonia supplied to the feed valve that 9 lb. is liquid and 1 lb. vapor. As this mixture passes into the evaporator a portion of it is evaporated in cooling what has been introduced at the temperature of the condenser down to the temperature of the evaporator; this is the dead work that always has to be done on the liquid ammonia, and is the reason why it is desirable to have the liquid as cool as possible when it reaches the feed valve. In the case where liquid only is supplied to the feed valve, the loss incident to cooling it is provided for in the size of the compressor. This loss is bad enough but in the case taken there is an additional loss, for the 1 lb. of vapor has to be condensed and the heat which it contains must be taken up by the evaporation of a part of the liquid ammonia, in this case amounting to about a pound, so that the available work of the 10 lb. introduced has been reduced some 10 per cent., and this loss is at the expense of compressor energy. Thus, while the compressor and other parts are doing their full duty the capacity of the plant falls off.

Just what percentage of the amount passing the feed valve can be vapor and yet the condition of a frosted feed valve be maintained, cannot be stated, but I have known of plants where the production fell off over 10 per cent. and still the frosted condition of the feed valve remained. This frost, however, to the observant eye showed a marked difference when nothing but liquid was passing through.

This condition of mixed vapor and liquid results from practically all the liquid being withdrawn from the receiver, at least enough to allow the outlet opening to be at times partially exposed. There are a number of ways in which this condition may occur. An engineer will get careless about watching the feed valve, and while the flooded system does not require the close attention that the expansion system does, yet it is not automatic. Now a feed valve may be so set that it will be hours before the condition referred to begins, at first very slowly, then faster and faster, until after a while the engineer notices that his tank temperatures are rising. If it has gone so far that the frost has left the feed valve he will be quick to notice what the trouble is. If not, he may blame it on the puller or the firemen, or just to pure depravity of the plant.

Where the charge of ammonia is low, this trouble is more likely to occur. A change in condenser pressure effects it, for the greater the difference between the high and low pressures the greater will be the flow through a given sized opening. Where the engineer has a gage-glass on the ammonia receiver, and this is watched, there is little likelihood of this trouble arising. It is such a simple trouble that one would hardly suppose it could frequently happen, yet it does to the discomfort of the engineer and the financial loss of the owner.

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A new method of removing hard scale from boilers is described in "Engineering." The apparatus (known as the "Pyro" boiler cleaning system) used consists of an oxy-acetylene blowpipe with two or three jets, a portable acetylene generator, a steel cylinder of compressed oxygen, and the necessary length of flexible tubing. When it is desired to remove any scale, the blowpipe flame is played upon it for a few minutes (depending upon the thickness of the scale) until the scale cracks and falls off due to rapid expansion under the high temperature. If the scale is slightly damp, the operation is assisted. Care should be taken to keep the flame from playing on the bare plate for any length of time. One of the advantages claimed for this method is that it can be easily applied to parts of a boiler where hand chipping is impossible.

EDITORIALS

When and What To Accept

A firm permits a man to purchase supplies and to select and have charge of new equipment for two reasons: First, because it believes his skill and experience fit him to better select than others in the firm's employ. Second, because it believes he will select honestly, i.e., that he will not allow his judgment to be warped or influenced by the "presents" and "tokens of appreciation" offered by bidders or those seeking to sell goods.

It is so easy to accept things you should not accept from persons with goods to sell. First you take a cigar; there is no harm in that. Then, perhaps, you are speaking of some peculiar steam troubles to a representative and he tells you that just that very subject is covered by a certain book and that he will be glad to mail you a copy. If your employer were in the office with you, you would not be ashamed to let him see you take a cigar or accept the book. But, suppose the coal dealer were sending coal to your house in return for the privilege he enjoys of supplying the plant with coal? You would not want "the boss" to know about that.

Do not accept anything that you would not want your employer to know about. That is a safe rule to follow.

⁂

Cinder Arresters in City Plants

With the increasing use of mechanical stokers, low-grade coals and the high draft necessary for economical combustion and overloads, the smoke and cinder nuisance becomes greater.

Smoke and cinders emitted from the stacks of industrial and central-station plants located in cities, not only pollute the atmosphere of the neighborhood, ruin clothes and deface architecture, but in many cases, particularly industrial centers, spoil the product of adjacent mills or factories. Textile mills, chemical works and factories making foodstuffs cannot be run well with closed windows during the summer, but chronically smoking stacks in the vicinity often make this necessary, much to the discomfort of the employees and consequently the output is decreased.

With the use of high draft and low stacks, both common in these days, this evil is augmented. Smoke-inspection laws and the intelligent coöperation of the smoke-inspection department does much to minimize the evil in any locality.

Cinder or spark arresters, placed in the stacks or main flues, while not a panacea for all smoke troubles, are effective in reducing the evil below the level of a nuisance. They are not complicated, their operation usually consisting essentially of passing the smoke and gases through a water spray, after the manner of the scrubber of a producer-gas plant or the air washers of some ventilating systems.

These arresters require so much water that usually they are not found in plants not adjacent to a source of cheap water supply. Unlike most apparatus, however, they do not require clear, clean water, and it is easily possible to return the water to the arrester after it has been separated from most of the combustion products. Possibly there is a serious objection to doing this. The sulphur dioxide formed during the combustion of the coal forms sulphurous acid when it unites with water. This acid is injurious to metals and when oxidized to sulphuric acid becomes more so. It may be, therefore, that this returned water would soon become such a corrosive agent as to be unfit for such use.

Much has been done of late years to design and construct boiler furnaces that will, with ordinary care, quite thoroughly combust fuels and thus keep down to a minimum the production of smoke. Cheap coals will be used, especially by big consumers, who are the ones to violate smoke ordinances most frequently. It is sometimes cheaper to pay the occasional fines imposed by the smoke inspection department than not to attempt to find means of burning a cheap and low-grade coal without more smoke and cinder than is allowed by the inspection department.

Usually cinder arresters are the only apparatus that make this commercially possible. If, therefore, a plant is in the congested part of the city and considerably distant from the ocean, lake or river front, and such a plant is a large consumer of coal and an old offender of the smoke ordinances, the city might find it expedient to supply water to the cinder arresters, through a separate meter and at a reduced rate.

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Boiler Inspection in England

The annual report of the management of the Manchester Steam Users Association for 1912 has just recently been issued and noted in POWER of June 10. The association is the first of its kind. It was founded by the late William Fairbairn in 1854, and the number of boilers under its supervision is 10,051 at 4564 works. The average income per boiler is about ten dollars and considerably over ninety per cent. of the boilers receive full examination throughout every year. The association conducts its affairs in lines very different from the insurance companies. It does not insure boilers, but inspects, reports and advises. If the owner follows advice up to a sufficient degree of compliance the association backs its inspection with a pecuniary guarantee of $5000 to $10,000, thus indorsing its inspection and offering to fine itself should a guaranteed boiler fail.

If advice is not well followed the association does not reject the boiler. So long as the fee is paid the inspections are made and the advice is hammered in, but the guarantee is withheld. When a boiler explosion was classed as among "the acts of God and the king's enemies" the withholding of the guarantee did not trouble some boiler owners very much. But today boilers cannot explode without an inquiry. And it is not even necessary

that anyone should be either hurt or killed. The inquiry follows just the same, though a fatality is apt to intensify the inquisition.

A boiler-explosion inquiry is usually a silly affair conducted perhaps by a man of no technical knowledge, who listens patiently to wigged barristers, who often do not know a rivet from a firehoe. But a considerable degree of publicity obtains and it comes to the surface if the owner has neglected the warnings given him by the inspection or insurance companies, and those who are responsible are charged to pay part of the costs of the inquiry and may even be indicted for manslaughter.

This and the thoroughness of boiler inspection may partly account for the high degree of safety secured, for only nine persons were killed by actual boiler explosions in 1912 and twenty-five were killed by steam pipes, kiers and sundry other explosions, whereas twenty persons were killed in October alone in the United States.

There cannot now be many boilers in Great Britain, which have not the rank of modern, for steel plates and drilled rivet holes after bending have been in vogue over 30 years, and the age of a boiler is rated at 25 years. The rise of pressures has helped to put most elderly boilers out of commission.

Whereas the methods of the association have set the tone in boiler-inspection work generally, yet the guarantee as opposed to insurance has not made much headway. The insurance companies carry on their books many times the number of boilers carried by the associations and have done good work, though occasionally they have lapsed somewhat for the sake of retaining business. Boiler owners have been prone to balk under the pressure brought to bear on them, and to retain their business too much leniency has been shown them in the way of excessive delays in canceling policies where recommendations are not followed. With the association there is no cancellation of policy, but simply a delay in giving the guarantee until the boiler and all its appurtenances are judged satisfactorily.

In the past the insurance companies through the competitive dickering which went on were exposed to conditions far from desirable. There is perhaps less of this now to contend with for it has ceased to be safe to take business on the basis of insufficient inspection or lenient rules of safety.

American coroners might well gain a few pointers from the above procedure. It is far from right to blame the dead engineer or fireman for an explosion for which the owner may be directly responsible. A few indictments at the right time and against some of the men higher up would have a desirable effect in tending to reduce the annual number of boiler explosions.

Unjust Criticism of Boiler Inspectors

Once in a great while we receive letters from disgruntled engineers, criticizing the work of boiler inspectors. Usually such letters are vehement and explosive in their condemnation of all boiler inspectors in general. If such communications were received frequently there would be reason to believe that the conditions they portrayed were actual.

The insurance boiler inspector is selected with great care. He must be not only a man who knows boiler-inspection work, but one who realizes that much depends on the thoroughness with which he performs his duties. Companies insuring boilers select their inspectors from among trained inspectors, foremen of boiler shops and from among high-class steam engineers.

It would indeed be difficult for an incompetent man to become an inspector. If he did get the job he would find it more difficult to hold it than he did to get it. Occasionally one is found who is negligent and he is promptly discharged when his company learns of it.

The number of inspections and visits made in a year in any particular locality depends on the law governing inspection in that locality. Where no state or municipal laws exist or where they are lamely enforced the number of inspections and visits is usually greater than where inspection laws are strictly enforced.

Usually, in any locality there are at least two inspections, one internal and one external, and the inspector visits a plant about four times a year.

Some engineers—the ones who write letters, such as referred to above—believe that the inspector should inspect the boilers every time he calls. They do not know that he calls to survey the morale of the force and the general condition of the plant. Consequently when they see him walk out without having crawled into the boilers they condemn him for performing perfunctory service.

Engineers who believe that the boilers under their charge are not being properly inspected should communicate with the insurance companies to adjust matters before they unjustly condemn the boiler inspectors. Gladly will we expose inspectors guilty of serious negligence or incompetence when specific evidence is furnished, but it would be obviously unfair to censure the whole profession on account of the shortcomings of a very few.

Uplift the Boiler Room

It is rather remarkable that so little attention is given by designers of average steam plants to introducing devices for removing ashes, which ordinarily is one of the most disagreeable and laborious tasks in the boiler room. While some attention is generally given to convenient handling of fuel, it is the rule rather than the exception that accumulations in boiler ashpits are permitted to be the source of most of the grime and dust that go to make the contrast in cleanliness between boiler plants and well kept engine rooms.

Progressive employers are not slow to recognize that lightening labor and improving the appearance of surroundings redound to their profit as well as the benefit of their employees, though suggestions of such improvements naturally must have their origin in the employee, and he will generally find those propositions most readily acceptable to his employer which promise a saving of money. No operating engineer or fireman need hesitate to recommend improvements that are money savers, but before proposing the installation of anything which is generally neglected he should be prepared to make its economic advantages clearly evident to the investor.

Any fireman or engineer who is tired of the old way of removing ashes from his boiler room should investigate every available mechanical means for doing the work. Then, obtaining estimates of cost of installation of the proper appliances, he can approach his employer with a money-saving proposition.

READERS WITH SOMETHING TO SAY

Hot Piers Prevent Smoke

This plant is located in the heart of the retail district, and is surrounded by business blocks, some of which are several stories higher than the one in which this plant is located; hence our trouble. Every time any smoke comes out of our stack our neighbors who have more time than business on their hands call up the city hall and register a kick about our stack. You all know that means trouble. We have 300-hp. Heine-type boilers, but only use one at a time. Our stack is 48x48 in. at the top and 160 ft. high. The draft over the fire is $^{23}/_{100}$ in., which, for the size of the boilers, is very low. We removed 12 in. of the lower baffle and the same amount of the top one (the baffles are horizontal). The reason for removing a part of the baffle is to increase the draft, which we did to $^{27}/_{100}$ in. We then put three brick piers in the furnace, being careful to have the space around them larger than the throat opening into the breeching. We have had no complaints since.

The function of these piers is to retard the flow of the gases and give them a rolling or whirling motion; they also serve to help burn the carbon carried off with the gases, as they are heated to a very high temperature. Two of the piers are set on the bridge-wall and are 18x24 in., and extend up within 1 in. of the tubes. The front pier is 24x24 in., and sets 22 in. ahead of the bridge-wall directly in front of the other two. With our type of stoker (sloping side grate) there is now no straight passage for the gases, and as they come in contact with the hot piers they are given a whirling motion and are also retarded a sufficient length of time to allow all, or nearly all, the carbon to be consumed. We also increased our evaporation about 1½ lb.

O. N. Pomeroy.

Lakewood, Ohio.

Worm-Gear Lubrication

There is a tendency to regard a worm gear as a suitable case for lubrication with thick, viscous oil, but in one instance the opposite was the case. A feed pump was driven by an electric motor through a worm and wheel; although the worm box was filled with a thick oil, after running for some time, the exterior of the casing about the thrust bearing became very hot, although the thrust was also immersed in oil.

While watching carefully, with a view to stopping the pump because of this heat, the casing became cool with almost startling rapidity. The heat had rendered the oil limpid and enabled it, presumably, to circulate better under the influence of the worm rotation and to flow not only more freely to the thrust bearing, but to work into both worm gear and thrust flanges. Thus the limpid oil better performed the duty of reducing friction than the thick oil.

In Lancashire cotton-mill practice the bearings of the rope-pulley shafts are supplied with a continuous flow of oil forced by centrifugal pumps. All these bearings are piped back to returns and the oil is filtered on its way back to the pump.

Can it be shown microscopically or by friction tests that such oil is any worse for a thousand passes through a loaded journal so long as the metallic or other impurities are filtered out? Oil is, when organic in origin, presumably built up of organic cells. If this is so, it is possible that its texture may be injured by heavy pressure on thin films. It does not seem possible to in any way injure the texture or nature of water having no organic structure. Unless overheated, oil has been regarded as equally nondamageable, except by absorption of oxygen. Is there not room for doubt on the subject, or has oil been so tested that it may be considered stable under stress?

William H. Booth.

London, England.

One of Many

One of the constantly occurring instances of old boilers being used under criminally dangerous conditions recently came to my notice. I was staying at one of the few hotels of which the town boasted. While in conversation with the porter he remarked upon the antiquity of the boiler used for heating the place. Being interested in steam plants of any kind, I persuaded him to let me have a look at the "plant."

I found a roaring fire underneath a boiler, which on looking at the gage-glass and trying the cocks, proved practically empty of water. The fire was immediately drawn. Investigation afterward showed that one of the return pipes of the heating system had frozen during a cold snap, and on the return of mild weather one of the pipes had burst, letting all the water out of the system.

The porter being new on the job, supposed that the boiler was under city pressure all the time, and that the water level was automatically maintained. He, therefore, had not touched the feed valve since his arrival about a week previous.

The boiler was 48 in. by 12 ft. and about 30 years old, and in that time had never to anyone's knowledge been cleaned. Imagine the amount of scale which would accumulate in that time with the use of city water remarkable for its hardness. Not only was the location of the safety valve unknown to the present owner, but he confessed ignorance as to its purpose. All the cocks and connections were leaky and most of the valves and cocks were minus handwheels, for which gas pliers served as a substitute. The steam gage was merely an ornament for I am confident that it had not moved from the zero mark in years.

If the boiler does not blow up in the mean time, a modern heating system will be installed this summer.

R. E. Durland.

Toronto, Ont., Canada.

Increases Feed Water Temperature

In a plant in which I was employed recently, the valve *A* was an ordinary globe valve. At that time, the exhaust from the main engines was run as follows: Valve *D* open, valves *C* and *E* closed, the steam going direct to the condenser. The auxiliary exhaust led through the heater and a bypass valve *A* to the atmosphere. With this arrangement, the feed-water temperature averaged 196 deg., which average we decided we could improve, and we made the following alterations:

The locknut on the inside end of the thread bushing in the yoke of the valve *A* was removed, thus allowing the valve to be operated without turning the stem, the thread bushing working back and forth in the yoke. All but one turn of the valve-stem packing was removed; a lever and weight were fitted, as shown, and a hole drilled and tapped in the valve bonnet, and a drain *F* connected to carry away the water that collected. Provision was made to obtain a higher back pressure than usual before opening. A steam gage was connected, as shown, and the drains from the heater and exhaust lines led to a trap sunk in the floor of the pit. The weight was adjusted until 7 lb. back pressure opened the valve *A*. With this arrangement, we obtained an average feed-water temperature of 206 deg., the temperature rising at times to 224 deg. The temperature was taken hourly and averaged for the 24 hours.

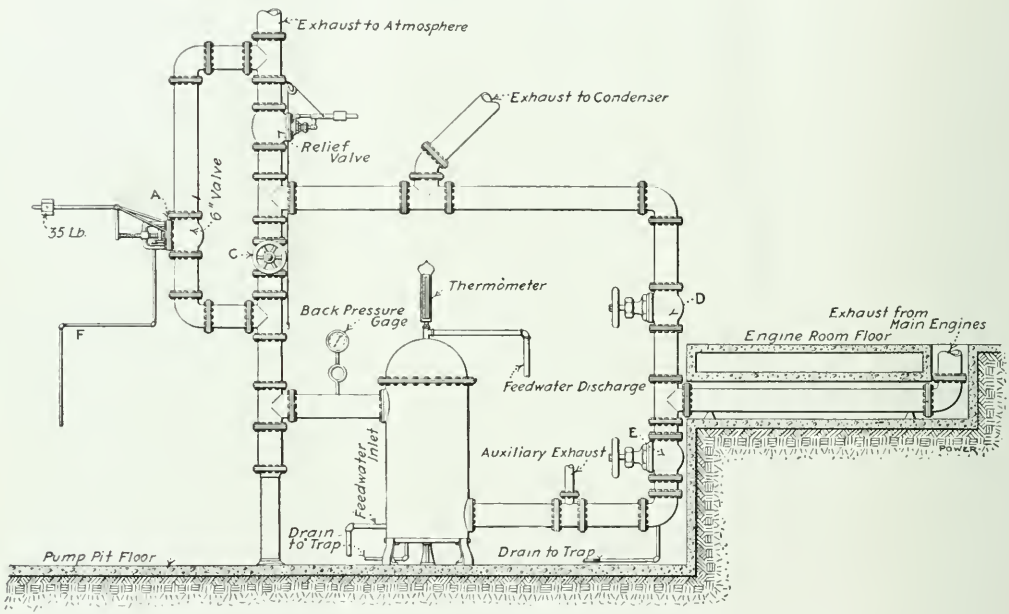
HENRY C. BRIGGS.

Jersey City, N. J.

[The pressure corresponding to a temperature of 224 deg. F. is 18.56 lb. abs., or 3.86 lb. gage; Marks & Davis Tables.—EDITOR.]

Steam Gages Inaccurate, Due to Plugged Pipe

In getting up steam one Sunday after cleaning the boiler, the engineer was surprised to hear the safety valve blow when the two steam gages showed only 35 lb. pressure with the valve set to blow at 120 lb. The valve closed as usual in a short time only to reopen when the gages indicated about 50 lb. pressure. It continued to act in this manner until the gages showed 120 lb., when everything went along as usual. The gages and safety valve were closely watched the rest of the week, but showed no signs of giving trouble. The following Sun-



PIPING TO HEATER, CONDENSER AND THE ATMOSPHERE

day the valve was removed and taken apart, but everything seemed to be in good order. On getting up steam again the safety valve commenced to blow at about 35 lb. pressure as before and continued to blow at about every 15 lb. increase until 120 was indicated by the gages. It was then decided that the springs were at fault and new ones were ordered and put in place. The new springs did not remedy the trouble, so the boiler inspector was called in.

He examined the valve and tested the gages and found them correct. The boiler was fired up again and acted as it had before. The test gage was then applied to a ½-in. pipe on top of the boiler and registered 120 lb. while the other gages only showed about 75 lb. This gave a clue to the cause of the trouble, which was found to be in the ¼-in. pipe to which the gages were connected. One gage was located above the water column while the other one was at the side of the boiler wall, both being attached to pipes leading from a tee connected by a short nipple to the top of the water column. This nipple had

been cut with a three-wheel pipe cutter and put in place without having had the burr removed from the inside of the pipe. This had reduced the opening about one-half, which gradually closed up until the gages could not record the pressure as fast as it increased in the boiler.

The pipe was replaced with new pipe reamed out to full size at the ends and the gages and the valve gave no further trouble.

E. E. Sidinger.

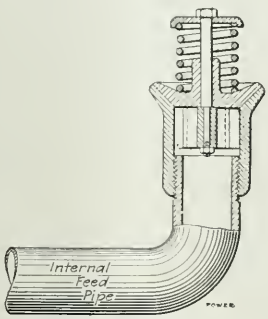
Salem, Ohio.

[Such experiences as the above serve to indicate the importance of keeping a strict check on one's gages and safety valves. It is a serious situation when a boiler has full pressure on it before the gages show it, even if it is equipped with a safety valve.—Editor.]

Makes Internal Feed Pipe

I had been considering the various arrangements of internal feed pipes to fit to my boiler, and I was aware that there were some objections to the use of a pipe delivering water into the steam space through perforations. The holes have to be large to provide against being blocked by sediment, etc., or the possibility of rupture by water-hammer.

For those reasons I decided to use a spring-loaded re-



Spring-Loaded Valve on Internal Feed Pipe

lief valve on such a pipe. My experience with the check valve showed that more pressure was necessary on the internal pipe to spray the water and this led to my conception of the arrangement shown in the sketch, which is a mitred valve with a wide seat. The spring used is an ordinary spiral one. This valve could be made in commercial sizes to screw onto any black-iron pipe. The idea is to maintain a pressure on the water to the point of delivery which would have the effect of delivering the feed into the steam space in the form of an umbrella spray. A thin film of water absorbs the heat of the steam before coming in contact with the water surface, thereby enhancing the circulation.

G. P. Melligan.

Levu, Fiji Islands.

Engineering in the Mining Country

About two years ago, having tired of the engine room, I decided to take a six months' ramble through the mountains of Nevada County and Sierra County, and ran across several mines and numberless "prospect holes." The plants at two of these were about the worst examples of engineering that I have seen for some time.

The first was located on Deer Creek, the hills on either side being about 400 ft. high. A tunnel was driven through the hill about 300 ft. above the mine and by means of a ditch and flume about 10 miles long, water was obtained for an undershot wheel connected direct to an air compressor; this, in turn, was the means of operating the hoist and also the drilling machines and pumps below ground. When I arrived they were just about ready to start up, and the next morning a man was sent up to open the gate at the tunnel.

All went well when starting, but after running about two hours they shut down to fix some leaks in the pipes. When starting up the second time with 100 lb. in the receiver the compressor refused to start and the man at the wheel of the gate kept opening up until the stream from the nozzle was strong enough to overcome the opposing force. I told the superintendent that what was needed was a connection whereby they could start the compressor against atmospheric pressure, instead of 100 lb. He replied that the man who had installed the plant had made a business of that kind of work for the past five years, and if he did not know how to set up a compressor he guessed no one did.

Later I learned that in starting up against 100 lb. pressure the waterwheel had gone to pieces, wrecking the compressor and depositing part of the remains on the other side of the creek.

About a month later I came across a small mine almost hidden in the timber. The hoist was of the vertical single-cylinder friction-drive type and with the exception of the engine was home-made. I believe the drum had been made out of the spool that the hoisting cable came on. An ordinary globe valve served as a throttle, and this was in such a position that the brake and clutch levers could not be reached from the throttle.

As I entered, the engineer had just received a signal to hoist. He got the engine up to a fair speed, then threw in the clutch and released the brake and jumped for the throttle, gave the engine more steam, then dropped down and helped on the flywheel until the speed picked up a little. He had to hoist a car about every 30 min., and while he was sharpening some drills in the blacksmith shop later on, he told me that on the first day (he had been there three days) he had experienced trouble several times when he failed to get to the throttle before the engine stopped and had to jump back and apply the brake, as the car had been raised several feet and if allowed to drop back might crush someone.

He said he always wondered when he received the signal if he would be able to get the men to the surface without the hoist going to pieces.

This hoist was what might be called a "first motion" or direct hoist as the drum shaft was direct connected to the engine crankshaft, the engine was not reversible, but the drum was free to revolve on its shaft. For the benefit of readers in California and particularly Nevada County, I might say that if they wish to look at this hoist, as a matter of curiosity, it is located about half way between Grass Valley and the little mining camp of Rough & Ready, on the right-hand side of the trail.

J. H. Stretton.

Los Angeles, Calif.

QUESTIONS BEFORE THE HOUSE

Removing Scale from Piping

Perhaps the method I have used to remove scale from oil-cooling coils and cooling jackets may be of interest to Mr. Hyde who asks for suggestions in the May 13 issue. The coils had become inefficient and a solution of one-half muriatic acid and one-half water was poured into each coil. It took several gallons. The coils being made of copper, the solution was left in the coil only two hours, and was then washed out with clean water. Two applications restored the coils to their original efficiency.

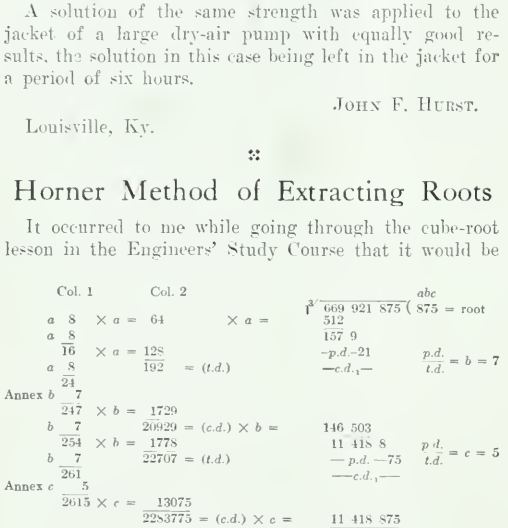
A solution of the same strength was applied to the jacket of a large dry-air pump with equally good results, the solution in this case being left in the jacket for a period of six hours.

JOHN F. HURST.

Louisville, Ky.

Horner Method of Extracting Roots

It occurred to me while going through the cube-root lesson in the Engineers' Study Course that it would be of interest to show how roots may be extracted by the Horner method given below.



In general, the given number is divided into periods (starting from the decimal point) each containing as many figures as there are units in the exponent.

At the left of the number, columns are arranged one less in number than the exponent. They may be numbered 1, 2. . . . (n — 1), from left to right. The first figure in the root (a) is found as usual, and its first power (a^1) is written at the top at col. 1; its second power (a^2) in col. 2, etc.; so that its n^{th} power (when exponent = n) is written under the first period. Subtract and bring down the next period for the new dividend. Go back to col. 1, add a^1 to a^1, multiply the sum by a, add the product to a^2 in col. 2; multiply the sum by a and carry to the next col., stopping at the last col. or col. (n — 1). This sum is the trial divisor (*t.d.*), the third number in column 2.

Repeat this process, stopping each time one column to the left, until the sum falls in the first column. This sum will be (an).

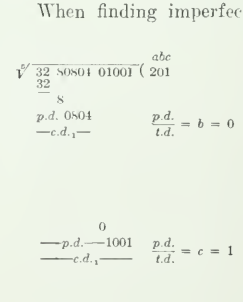
The partial dividend (*p.d.*) is the remainder, with the first figure only of the annexed period. Then

$$\frac{p.d.}{t.d.} = b = \textit{second figure in the root}$$

The complete divisor (*c.d.*) is found by annexing b to the sum in col. 1, one place to the right, multiplying this by b and adding the product to the sum in col. 2, two places to the right, multiplying this sum by b and adding to the sum in col. 3, three places to the right, etc., until it stops in the last column (n — 1) places to the right. This sum is the complete divisor (*c.d.*). Multiply it by b and subtract it from the complete dividend (*c.d.*).

These processes for finding the trial and complete divisors are repeated until the root is found, or found to as many decimal places as desired. The last figure written in the root at any one time is the only figure used for adding and multiplying, so that multiplying from one column to another is done without the necessity of setting down the figures.

When finding imperfect roots, one less decimal than those already found can be obtained by partial division. For each decimal so obtained cross out (n — 1) figures from the right end of the last complete divisor, and (n — 2) figures from the last remainder, using these for divisor and dividend respectively. This is true for any method. The Horner method is easily learned and very convenient to use.



PORTER STAFFORD.

Erie, Penn.

Pumping-Engine Water-End Diagrams

Recently I took the accompanying diagrams (set No. 1) and in looking through back numbers of POWER for diagrams for comparison came across those shown by John Burnes in the Oct. 15 issue, and here referred to as set

No. 2. Set No. 1 was taken from the water end of a vertical, triple-expansion pumping engine 24, 46, 70 and 34 by 60 in., designed to pump 25,000,000 gal. every 24 hr. against a head of 140 ft. at 25 r.p.m. The diagrams submitted by Mr. Burnes, or set No. 2, were taken from a vertical triple-expansion, pumping engine, 28, 54 and 80 by 60 in. with a capacity of 20,000,000 gal.

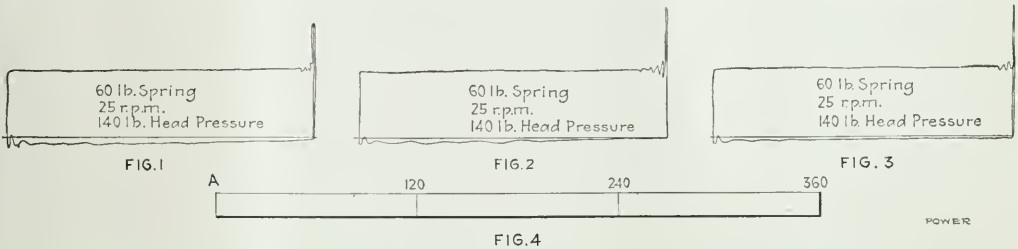
In comparing them I can find but two points in common, that is, the great increase of pressure at the commencement of the discharge stroke, and the few waves or pressure fluctuations at the beginning of the suction stroke.

Mr. Burnes thinks that the great excess of pressure over the actual pressure in the water main, as shown in his diagrams, to be due to the inertia of the valves. The pressure was due to inertia offered by the water, pump valves, valve springs and the indicator spring.

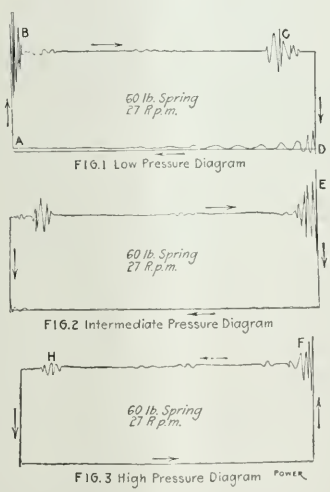
It is noticeable that, even though the excess pressure is higher in the case of set No. 1 than it is in set No. 2, the accordion effect is not nearly so pronounced. I think a remedy could be found for this in carrying plenty of air in both the discharge- and suction-air chambers. During the time of taking set No. 1 water was not allowed to rise more than 6 in. from the bottom of the gage-glass, and the bottom of this glass is about 8 in. from where the air chamber tapers to enter the discharge main.

Due to the incompressibility of water (0.000040 to 0.000051 for one atmosphere, decreasing with increase of temperature. Kent, page 551), any deviation from a uniform discharge pressure must work to the detriment of those parts that resist the shock, thereby necessitating more frequent keying up and more careful attention to all bolted connections intermediate to the steam system and pump pressure.

The wavy lines at the commencement of the suction stroke, I believe to be less preventable in the case of set No. 1 than in set No. 2, although the pump, through a 42-in. suction takes water from a well supplied by a 9-ft. tunnel, there is not the facility for keeping the suction head from varying as in set No. 2.



Diagrams (Set No. 1) from Water End of Triple-Expansion Pumping Engine



Diagrams (Set No. 2) from Water End of Large Pump

The irregularity near the end of the discharge line I never saw on a pump before, and do not know the cause unless it could be insufficient air chamber capacity. I could just as readily tell at what per cent. of stroke cutoff takes place by carefully watching the valve positions as I could tell the relative position of any two cylinders in passing a given point. Mr. Burnes' analyses of this cause may be correct, but his method does not carry conviction. The following method of determining this point could, no doubt, be improved upon, but I believe for practical purposes it is sufficiently accurate.

The length of the diagram represents diagrammatically the length of stroke or one-half a revolution, twice the length of diagram is, therefore, a total revolution, and as in this case the engine is a cross-compound with three cranks set at 120 deg. apart, each crank will pass a given point 120 deg. ahead of the following one. By taking a narrow strip of paper, Fig. 4, twice as long as the mean length of the indicator diagram a close approximation of a complete revolution is obtained. Consider this Fig. 4 as representing 360 deg. and point A as the commencement of the stroke of any one cylinder, the position of the other two cylinders will be

$\frac{1}{3}\frac{2}{6}\frac{0}{0}$ and $\frac{2}{3}\frac{4}{6}\frac{0}{0}$

of the total length of the strip measured from point A.

Starting with the high-pressure diagram, place point A of the strip on the line on the card indicating the commencement of the discharge stroke, and by repeating the same operation for the intermediate pressure and the low-pressure cylinders against the lines marked 120 and 240 deg., the points where these diagrams or one part of the stroke overlaps the other is readily determined.

Chicago, Ill. James W. Beatty.

[Crosshead and crank travel are not constantly proportional. At one-third of a revolution the piston would not cover exactly two-thirds of its stroke.—Editor.]

INQUIRIES OF GENERAL INTEREST

Size of Safety Valve—Does a boiler carrying 100 lb. pressure require a larger safety valve than one carrying 25 lb.?

F. M.

No, not so large, other things being equal. According to the best modern authorities, the area of a safety valve should be proportioned directly as the amount of water evaporated by the boiler and inversely as the pressure which the boiler is to carry.

Jam Nuts—When two nuts are used on a bolt, one a jam nut or lock nut for the other, if one nut is thicker than the other, which should be put on the bolt first.

H. S. C.

The thick nut should be put on first, for, having more threads, it can be drawn up tighter with less danger of stripping the threads, and on account of its greater thickness it can be easier held by a wrench while the outside nut is turned.

Cleaning Smoky Burette—What will clean a dark, smoky deposit from a gas-analysis burette?

J. W. D.

If the burette is discolored with an oily deposit it can be cleaned with gasoline; if discolored with a deposit of carbon, kerosene should remove the smoky appearance. If the glass has been discolored while hot, it may be difficult to remove the stain without soaking the glassware in the cleansing liquid for some time, occasionally scrubbing it with clean cotton waste.

Connecting Exhaust Injector—What is the best way to connect an exhaust injector to a boiler?

P. W.

Take the steam out of the upper side of the engine exhaust pipe at a point where it will be as dry as possible and as little reduced in pressure below that at which it was discharged from the engine as possible. The connection should nevertheless not be too near the engine because the pipe between should be long enough to act as a receiver so that the injector supply may be fairly steady. The connections of the injector suction pipe and the discharge to the boiler should be as direct as possible, with few ells and bends, and the connection to the boiler should contain a check and a stop valve.

Piston Clearance—How may the piston clearance at each end of a cylinder be determined?

R. J. B.

The engine is put on center at each end of its stroke and a mark made on the guides registering with a mark on the crosshead. The connecting-rod is then disconnected from the crank and the piston moved as far as it will go each way, i.e., until it strikes the heads. Marks are then made on the guides registering with the first mark on the crosshead. The distances between the two marks on the guides at each end of the crosshead travel show the linear piston clearance at the corresponding cylinder ends. If the volume of clearance is desired the piston is moved first to one end, then the other of its stroke, and the measured amount of water required to fill the clearance space back to the valve seat shows the clearance volume, and whether or not it is equal at each end of the stroke.

Stay-bolt Sizes—How does one determine the size of stay-bolt required for a given pressure and pitch?

O. W.

If the pitch of the stay-bolts is s, in inches, the area supported by each stay-bolt is $s \times s$ and the pressure $P = s \times s \times p$, where p is the pressure in pounds per square inch. Knowing the total pressure P on each stay-bolt the required area of cross-section is P divided by the allowable load per square inch on the stay-bolt. The threaded part of the bolt must have a cross-sectional area at the root of the thread not less than the above. From this area, a, the diameter of the required bolt d is found from the formula

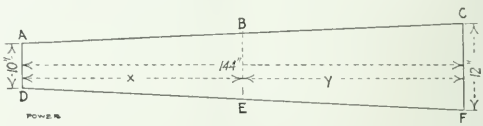
$$d = \sqrt{\frac{a}{0.7854}}$$

If the bolt has 12 threads to the inch the diameter over the outside of the thread should be

$$D = d + 0.1443,$$

according to the Massachusetts boiler rules. By the same rules the allowable load per square inch on wrought-iron or mild-steel stay-bolts up to and including 1¼-in. is 6500 lb., and for larger bolts 7000 lb.

Halving Trapezoidal Area—In a trapezoidal figure, dimensioned as in the diagram, where should a perpendicular



line BE be drawn so that the areas ABEDA and BCFEB will be equal?

C. J. B.

The area of a trapezoid is equal to half the product of the sum of the bases by the altitude or in this case

$$\frac{(10 + 12) \times 144}{2} = 1584 \text{ sq.in.}$$

is the area of the whole figure.

Let

x = Altitude of trapezoid ABEDA
y = Altitude of trapezoid BCFEB

AD is given as 10 in.
CF as 12 in.
Let BE = a.
Then the area of the trapezoid ABEDA is

$$\frac{(10 + a)x}{2}$$

and, by the conditions is to be equal to the trapezoid BCFEB, or

$$\frac{(10 + a)x}{2} = \frac{(12 + a)y}{2} \qquad (1)$$

Since both together equal the area of the entire figure, 1584 sq.in.,

$$\frac{(10 + a)x}{2} + \frac{(12 + a)y}{2} = 1584 \qquad (2)$$

It is also known that

$$x + y = 144 \qquad (3)$$

With the three equations (1), (2) and (3) the three unknown quantities can be determined, but in this case only x and y are needed so a may be eliminated.

Equation (1) reduces to

$$(10 + a)x = (12 + a)y$$

$$a = \frac{10x - 12y}{y - x} \qquad (4)$$

Equation (2) reduces to

$$(10 + a)x + (12 + a)y = 3168$$

$$a = \frac{3168 - 10x - 12y}{x + y} \qquad (5)$$

Equating (4) and (5)

$$\frac{10x - 12y}{y - x} = \frac{3168 - 10x - 12y}{x + y}$$

$$(10x - 12y)(x + y) = (y - x)(3168 - 10x - 12y)$$

$$3168y + 4xy = 3168x \qquad (6)$$

$$y = \frac{3168x}{3168 + 4x}$$

From equation (3)

$$y = 144 - x$$

Then

$$\frac{3168x}{3168 + 4x} = 144 - x$$

which reduces to

$$x^2 + 1440x = 114{,}048$$

Completing the square

$$x^2 + 1440x + (720)^2 = 114{,}048 + (720)^2 = 632{,}448$$

$$x + 720 = \sqrt{632{,}448} = 795.266$$

$$x = 75.266 \text{ in.}$$

and from equation (3)

$$y = 144 - 75.266 = 68.734 \text{ in.}$$

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis—Part II

Unpacking and Assembling Apparatus

The Orsat apparatus is shipped knocked-down; that is, the glass parts are taken out of position and securely packed so as to avoid breakage. The first thing to do, then, is to get the apparatus properly put together again.

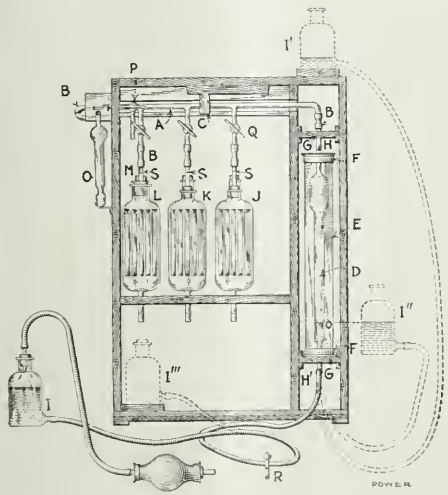


Fig. 1. Diagram for Assembling Orsat

If you purchase an Orsat-Muencke, the following directions will serve as an exact guide. If you happen to purchase some other type these directions may have to be modified slightly, but the modifications will be self-evident when you come to examine the parts. The directions I will give for preparing the chemicals and operating the apparatus can be followed exactly with any of the standard types of Orsat.

After carefully unpacking the box in which the apparatus is shipped and making sure that you have not missed anything, dust off the cabinet and wash the glass parts with warm water and soap, rinsing thoroughly in clean water at the end. Take both front and back slides out of the cabinet and place it before you so that the long, narrow compartment is at the right.

Next, put the header *A*, Fig. 1, in position, first making sure that the five rubber connectors *B* are in place ready to make the connection between the header and the other parts. The header is held in place by the small wooden latch *C*; be sure that this is in the closed position before proceeding.

The next step is to fit the burette or measuring chamber *D* into position. This burette is provided with an outer case *E*, of glass, for the purpose of preventing error due to change in the temperature of the air in the room affecting the gas in the burette. The space between the outside case and the burette should be filled with clean water. As the rubber corks *F* both contain vent holes, the one in the bottom cork will have to be plugged up after the water is run in. See that the white side of the case with the blue stripe down the middle comes on the side opposite to the scale marks on the burette. This white and blue background makes it easier to read the water level in the burette when measuring.

Having the casing filled with water, the next step is to connect the burette with the header at the top. Put the two small sliding shelves *G* over the stems *H* and *H'* and fit the shelves into their grooves. This will hold the burette in position so that you can use both hands for slipping the rubber connector over the stem. Be sure that the stem is moistened with water as this will make the rubber slide much more easily. Draw the top shelf out a little so

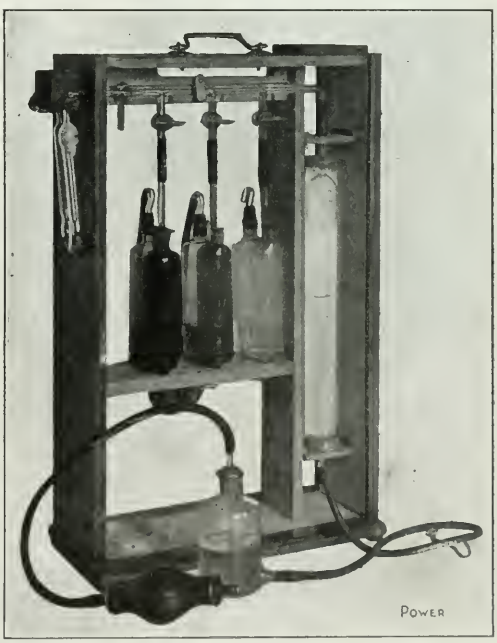


Fig. 2. Front View of Assembled Apparatus

that the stem does not come directly under the header end, then gently work the rubber connector over the stem until it fits snugly with the weight of the burette resting on the bottom shelf. This will keep strain off the header. Great care will be necessary in the making of these connections as the use of too much force will result in breakage.

Two pieces of rubber tubing come with the apparatus. The longer piece is for making the connection between

the burette and the leveling bottle *I*. Before making this connection, slip one of the pinch cocks on the tubing, as this will come in handy to regulate the water level when making analyses.

Next, the pipettes *J*, *K* and *L* are put into place. These pipettes consist of two bottle-like parts connected at the bottom by means of a glass neck. The construction of the pipettes varies somewhat with different apparatus. Some, such as *J* and *K*, have the stem *M* connected solidly to the bottle part while with others, such as *L*, the stem forms part of a stopper which makes a ground-glass fit with the neck of the bottle part.

A number of small glass tubes are furnished to insert in the front leg of each pipette. These tubes may come

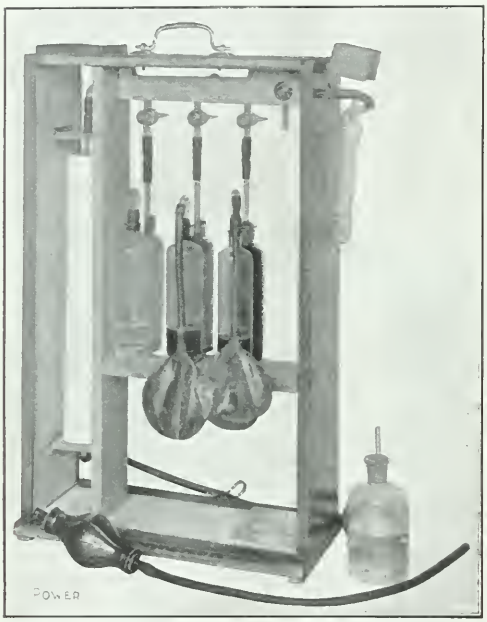


FIG. 3. REAR VIEW OF ASSEMBLED APPARATUS

already in place. If so, there may be some cotton wedged into the bottle above them to prevent them rattling and possibly becoming broken in shipment. This cotton must all be removed. If the tubes do not arrive already in place fill the front leg of two pipettes as full as you can with the plain tubes and the front leg of the third pipette with the tubes which have little spirals of copper wire in them. Be sure that the pipettes are arranged in the cabinet in the proper order; the two nearest to the burette should contain the plain glass tubes while the farthest one should contain the tubes with the copper spirals. In time these copper spirals will become dissolved by the solution used in this pipette and new tubes containing spirals will have to be purchased and put in.

Into the back leg of each pipette fit a goose-neck stopper, as shown in Fig. 2, and to the goose-necks of the two pipettes furthest away from the burette attach the rubber gas bags, as shown in Fig. 3. The object of these bags is to prevent air from coming in contact with the chemicals in the pipettes and spoiling them. The chemical in the first pipette need not be so protected.

The U-tube *O*, Fig. 1, is next attached to the end of the header, as shown, and the apparatus is ready to load and use. This U-tube has a wad of mineral wool in its open end and serves as a filter for the gases before they enter the apparatus, catching any particles of dust and soot which might otherwise foul up the header and cause trouble in the glass cocks. It also can be filled with small lumps of calcium chloride for absorbing moisture from the gases. This, however, is not absolutely necessary.

I would advise all beginners to practice loading and manipulating the apparatus with plain water before putting in the chemicals, as the latter are nasty to spill or slop around as well as somewhat too expensive to deliberately waste. So, until you fully understand how the analysis is conducted, plain water is the safest and cheapest material to experiment with.

Analyzing Boiler Tests*

By A. Bement

One of the features of difficulty which interposes itself in the analysis of a boiler test is the correct measurement of the temperature of the escaping gases. As a rule, it is necessary to calculate a heat balance before any analysis of results can be attempted. This requires a knowledge of the temperature at which the gases leave the boiler and correct measurement is really very difficult. This will surprise most people, as it is generally felt that such measurement is very simple. The difficulty of this measurement has two phases, one has reference to the location of the measuring instrument, the other to the heat conducted away by the instrument and by the walls of the flue in which the instrument is located.

Assuming a uniform air supply as existed in the Detroit Edison tests, it necessarily follows that the volume of the gases is in direct proportion to the coal burned, and the large capacities were obtained with the large coal consumption. Therefore, the high rates of evaporation were accompanied by large gas volume and the low rates by small volume. In each condition, however, the flue area and gas passage being the same, the natural result is that the flowing gas volume, seeking the path of least resistance, would not fill the flue in the case of the small volume of gas; or, in other words, the center of the gas volume would not be the same in all cases.

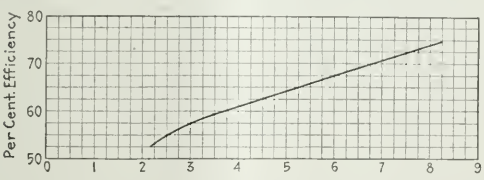
The location of the measuring instrument with reference to the *flue* remains constant, but with reference to the *flowing gas body*, it is not constant. For this reason the gases come in contact with the measuring instrument to a greater or less extent, depending on the amount of the gas flowing. The prevailing tendency of this condition is to cause the temperature to appear too low with small capacities and too high with large ones. It is apparent that the quantity of the heat radiated from the flue and from the measuring instrument is approximately constant, because the area of the instrument and of the flue are constant for all conditions. The quantity of the gas flowing through the flue is, however, a decided variable, it may be three or four times greater at high than at low capacity. The quantity of heat lost at high capac-

*Supplementary to "Steam Boiler Efficiency," by same author in the preceding issue.

ity is a comparatively small percentage, and the quantity lost at low capacity is a large percentage, the result is that the heat lost in hot gases at high capacity appears higher, and at low capacity lower than it should. In this way we are probably caused to consider chimney losses to be greater than they are at high capacity and less at low. This being true, we have another reason for assuming a constant efficiency, as illustrated in the diagram in last week's issue.

The foregoing discussion has reference to those cases where the data is derived from a heat balance, wherein the above mentioned cause, and that of incomplete combustion by escaping hydrocarbons are generally important and unknown variables, both of which make the loss at high capacity appear higher than it is. Therefore, if we could take direct results from tests without the intervention of a heat balance, we would eliminate some of the difficulties of dealing with it. It would, however, be necessary to have complete combustion, a uniform loss of fuel in the ashes and a constant air supply, all of which are hard to obtain in usual practice.

In looking over his data for a case that might be of service, the author finds the performance shown in the curve herewith, which comes nearer, from a theoretical



standpoint, to meeting these requirements than any other extensive series of tests that he has. These tests, some 60 in number, were all run on one of the boilers of an important power plant, and the efficiency shown is derived directly from the evaporation, without any correction for fuel lost in the ashes or anything else. While the points are not shown in the diagram, the location of the curve is copied from the original record, and so its accuracy may be depended upon. This diagram shows the efficiency as ranging from 52 per cent. at 2.1 lb. evaporation, to 75 per cent. at an evaporation of 8.25 lb. per sq.ft., a difference in efficiency of 23 per cent. The coal used was of a variable quality, which had something to do with the result.

It is possible to account for 12 per cent. of this lower efficiency by the higher ash content of the coal that was used in the low efficiency tests. This leaves a difference unaccounted for of 11 per cent. and it would be necessary to assume that this was due to unfavorable size of coal, to bring the result down to a constant efficiency for the full range of capacity shown by the diagram.

Thus it appears when an effort is made to analyze even such elaborate data as these, we are confronted with a difficulty, not in being unable to boost the efficiency at high capacity, but in finding a justification for bringing the efficiency of the low capacity up to it. At all events when large coal users obtain results shown in the diagram, they are disposed, not only to be satisfied, but to feel that it might be a good thing if the Bureau of Mines would spend some more money for additional study.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Marcel G. Brindejonc des Moulinais flew 674 miles in 7 hr. 4 min. Any aviator who can hoist the name alone is some derrick. It's long enough for a tail to a kite.

⁂

"A college education is worth $25,000 in increased earning capacity," declares a Western university. It is, and it isn't. There are college men who could not earn this sum in 25 years; there are men earning twice as much in a year who never even walked by a college. It's a fine thing to have, but its earning capacity depends upon the practical use made of it.

⁂

Some tall and towering things have been served to you in "Power," and if you turn back to page 884 you'll see that we are still soaring. This time it's the Woolworth Building power plant—910 ft. from bed rock, suh; meaning the building. It takes miles of things to operate this plant, and Thomas Wilson has it all in the story. And a "5- and 10-cent" idea made this beautiful building possible.

⁂

Arrested for non-support, a New York man testified that he gave his wife a dollar the other day to buy food. "When she returned, she had an onion, a bunch of radishes, and a jag!" said he. While the return shows a rather low load for the eats, the peak stands right up on its hind legs. And all for a dollar!

⁂

Our newest "contemporary" is the "Hobo News." As somebody has to work to get this paper out, isn't this heresy and schism in the minds of the craft? Any advertising in the "News"? Canned goods and soaps might make a hit.

⁂

The "code" microbe is gnawing the vitals of some of the professional engineers. They must have a code to define what's what and who's who. After wading through a column of this stuff we come to the conclusion that the dope is a reiteration of "Be honest, and don't slam the other fellow." Good gosh! You and I learned this back in the little old red schoolhouse days—and the most of it still sticks, doesn't it? Bimeby, people will become suspicious if a learned society thinks it necessary to make a publicity campaign on honesty alone.

⁂

Our cartoon this week sure shows the situation in some power plants. When things are slipping along to the satisfaction of Mister Boss, the engineer who wants to disturb his complacency with a suggestion is about knee-high to a peanut. When the motive power lays down and refuses to mote, it's Mister Engineer who looms large in the picture.

⁂

You should be exceeding glad that the advertising men are going to yank the "crook" out of crooked and put a capital H on Honesty. And their recent convention in Baltimore gave added impetus to this campaign. How will it benefit you? This way: Your Helen won't buy a sealskin sacque and have the village chemist analyze it as "cat;" you won't pay $1.15 for your $2.50 negligee shirt, and find it was marked down from 59 cents; your wool duds won't turn out to be just shoddy; your genuine Panama Hat won't be grown in Connecticut; the impure fooders and the expired patent medicines won't— There's going to be better times when these ad men further exploit the Truth and put a crimp in the fakers.

⁂

This column is being written on Friday, June 13, 1913, but we've packed our rabbit's foot and crossed our fingers, so why should we worry and raise a wrinkle? We'd even accept a raise of thirteen silver dollars if we thought the Old Man would try to hoodoo us that way.

Saturday, June 14. Nothing happened, none of it.

⁂

Today, being Flag Day, every lovely girl and every mere male editor on the staff wears Old Glory on his or her manly or otherwise bosom. Even the dude editor's cane is doing duty as a flagstaff. The Stars and Stripes should wave over every power plant in the land. How about yours?

Stewart's Experiments on Indicators

By Julian C. Smallwood

SYNOPSIS—The author points out that variation of friction for different springs has not been sufficiently proved; that for precise calibration the temperature, speed and other conditions present should be more nearly identical with those which obtain in practice; and proposes more correct methods of calibration.

The paper presented by James G. Stewart before the Institution of Mechanical Engineers, a review of which appeared in the June 17 issue of POWER, page 851, is a valuable contribution to indicator science and practice. It would seem, however, that the results of the variation of friction with spring stiffness are not sufficiently proved. If Mr. Stewart's reasoning is correct, that it is caused by an imperfect cylinder or cylinder cap, it would have been less or nil with a truer instrument. It is unfortunate that other sets of results covering this point were not presented.

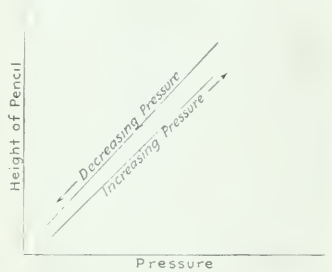


Fig. 1. Indicator Spring Calibration Curves

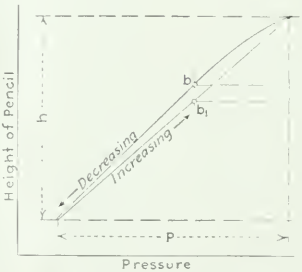


Fig. 2. Calibration Curves for Correcting Fig. 3

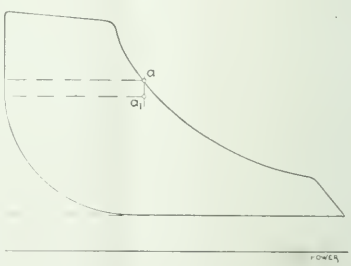


Fig. 3. Indicator Diagram

All the tests were made with compressed air as the pressure medium, so that the conditions of temperature and working fluid do not apply to the general case. This will cause a difference between the errors experimentally found and those in usual operation, but it is likely that, in the latter case, they will not be any less.

It does not seem to be entirely proved that the friction is independent of speed, as Mr. Stewart assumes, or that it is constant for a given set of oscillations. Nevertheless, the results as a whole must be considered trustworthy, and that, therefore, past experimenters have not appreciated the magnitude of the errors discussed.

The present writer has been working toward Mr. Stewart's ends, though by different methods, for some time past, with a view to the construction of an accurate method of correcting indicator-pencil motion, being led to do so by the following considerations: The usual calibration is accomplished by a more or less jerky variation of motion and pressure. This does not duplicate the actual condition of pencil friction or of pencil motion, which latter might, so the present writer considered, easily affect the friction. Further, when the observations of such a test are plotted, two unconnected curves result, as Fig. 1; whereas, in actual operation, the relation between pressure and height is a continuous one, with no unfilled gaps at the ends. Certain researches along kindred lines indicated that the decreasing relation may not be represented by a straight line, but by a curve, as shown in Fig. 2, joined at the ends to the line for increasing values. This applies to any instrument of precision depending upon springs, and, probably, to all indicating instruments. That is, if an instrument, such as an indicator, is true for increasing values, it must be untrue for decreasing values. This phenomenon is due not only to friction of bearing surfaces, but to internal friction of the spring itself, the effect being similar to hysteresis in magnetism. From the present writer's experiments, it appears likely that the relation between the force on a spring and its deformation is different for different ranges of force, and that friction is less, regardless of the absolute pressure, the less is the range, a point which seems to have escaped Mr. Stewart's attention.

It appears, then, that to calibrate an indicator spring with precision, it should be tested under a gradually rising and falling pressure, such as actually obtains in a steam or gas engine, the limits of the pressure being the same as those of the indicator diagram to which the results are to be applied. The problem presented was to design a steam container equipped with a valve or valves to accomplish this variation, and with an apparatus for obtaining an autographic diagram, such as Fig. 2. The test gage for measuring the true pressure must itself be sufficiently free from friction to give substantially true decreasing readings.

An attempt was made to satisfy these conditions as follows: A recording-pressure gage having a pressure tube of the helical type with pen arm directly attached was found to have very little friction, and so was used to measure the true pressure. The clockwork was detached from the dial, and a small wooden drum placed on the dial spindle instead. The gage and the indicator to be tested were both connected to the pressure chamber in which it was attempted to vary the pressure by hand manipulation of valves. One cord was passed around the indicator drum and another around the drum on the gage-dial spindle, so that when the cords were pulled together, the dial and the drum would have similar motions. By comparing the corresponding records of height of pencil on the indicator card and true pressure on the gage blank, data for a curve similar to Fig. 2 could be ob-

tained. The apparatus has not yet been developed enough to yield satisfactory results. The method is inferior to Mr. Stewart's in that error is introduced because of elastic hysteresis of the pressure gage.

With such a diagram as Fig. 2, the indicator diagram could be readily corrected as follows: The two diagrams are laid side by side, as shown by Figs. 2 and 3. The true scale for ascending values on the indicator diagram (that is, values on the compression line) is given by P and h. To represent the point a, Fig. 3, on this scale, the construction $abb'a'$ is used, the point a' being the required corrected position of a. Enough points are thus corrected to determine a corrected expansion line. The ascending spring scale will then apply correctly to the whole diagram. This method appears to be less laborious than Mr. Stewart's, and, because the calibration is affected by the *range* of pressure, more accurate.

Returning to Mr. Stewart's paper, his results on the drum-motion investigation call for little comment, in that, experimentally, they only brushed the surface of the subject. His method was the one used by Mr. Brightmore, namely, getting a number of correct positions of the drum by an electric spark at the pencil point, made by commutator contacts on an engine crosshead driving the indicator. Apparently he obtained results on only a single set of conditions. Strictly speaking, the errors in the drum motion shown by his curves are not effective errors as was shown by the present writer in an article on "Distortion of Indicator Drum Motion," in the Aug. 20, 1912, issue of POWER. The effects of friction of the drum spindle and of guide pulleys, also given in this publication, have not been touched upon at all, and these are by far the most likely and largest sources of error in drum motion.

It is interesting to note, in closing, that, whereas the effect of friction in the pencil motion is to make the indicator diagram larger, on the drum motion it is to make it smaller, and these two errors often counterbalance sufficiently to give reasonable results. The net effect is to make the usual indicator fairly reliable as an instrument to measure mean effective pressure, but for other uses its design may be much improved.

Bursting Flywheel Causes Two Deaths

SYNOPSIS—A flywheel explodes, bursting two main steam pipes, causing the death of an oiler and the engineer.

The engine room of the Alpha Portland Cement Co. was the scene of a fatal flywheel accident at 2 a.m., Monday, June 9, resulting in the death of two men, both employed in the engine room.

The engine room contained three cross-compound main power units and a turbine-lighting set. The three main engines were each fitted with a sheave flywheel used to drive as many line shafts by the English system of rope drive, i.e., each rope independent of the other.

Two of the line shafts ran across the end of the engine room, as shown in Fig. 1. The engine at the right was rope connected to a third countershaft, as shown at the

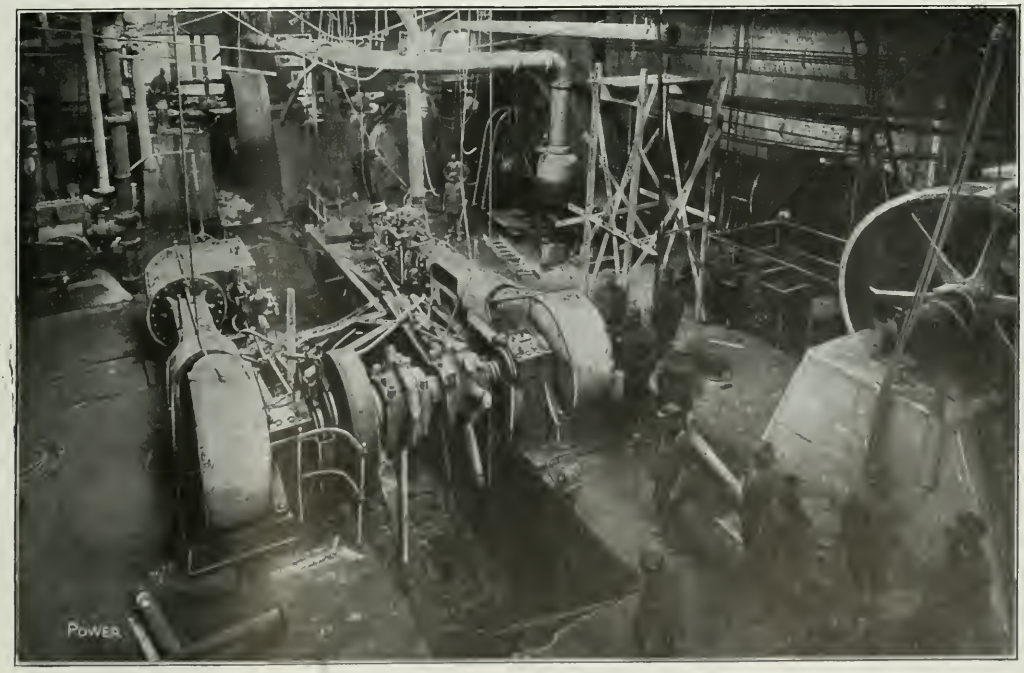


FIG. 1. VIEW OF THE WRECKED ENGINE FROM THE CRANK END

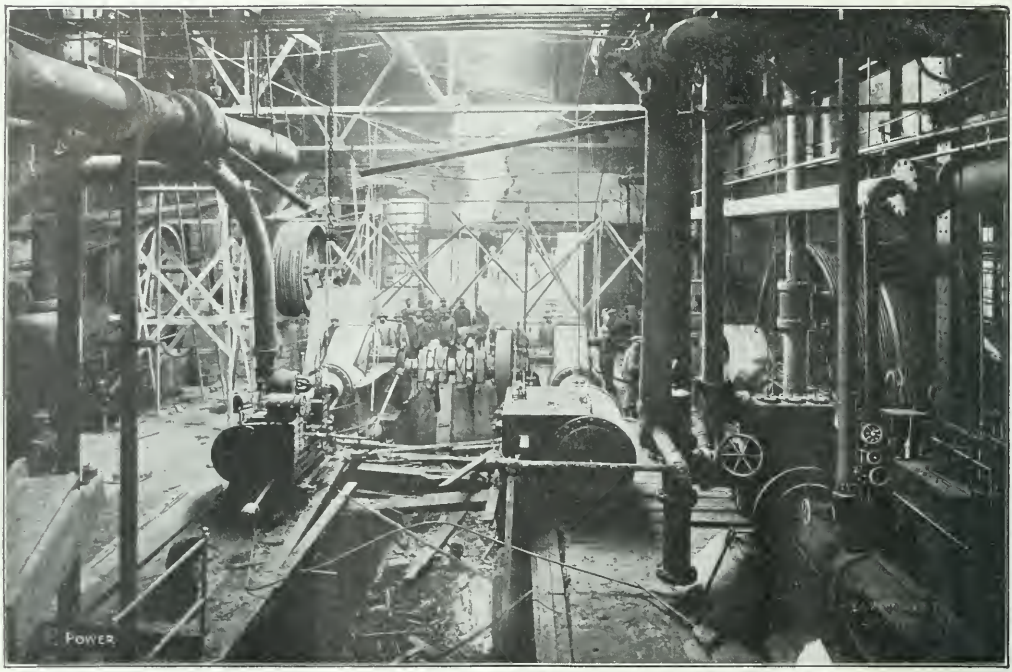


FIG. 2. SHOWING ENGINE AND DAMAGED WALL CAUSED BY FLYWHEEL EXPLOSION

left of Fig. 2. The engine at the right of Fig. 2 drove the first shaft, shown in Fig. 1, which also carried an idle sheave wheel in line with the right-hand half of the flywheel of the wrecked engine. The second line shaft, at the rear of the first, was rope driven from the other half of the flywheel.

This flywheel was in reality two sheave wheels made in half sections with split hubs, each held together by four 2-in. bolts. Fig. 1. The rim joints of each wheel section were secured with five 1¾-in. bolts. The adjoining edges of the wheel rims were flanged and the two sections, thus bolted together, formed the flywheel as a whole. It was 18 ft. in diameter, with a 70-in. face, which was made with 26 grooves, and ran at a normal speed of 90 r.p.m.

Both the flywheel and driven sheave wheel were demolished while the idle sheave wheel on the front line shaft was found whole, with the exception of a small piece that had been broken out of the edge of the rim. When the flywheel burst a 7- and a 9-in. steam main were broken and the steam from 3000 hp. in boiler capacity escaped, filling the engine room with live steam, which, from all indications, was the cause of the death of Herbert Buskirk, engineer, and Edward J. Butler, oiler. Engineer Buskirk was found lying at the edge of the wheel pit shown in the foreground of Fig. 1; Butler was found next to the wall at the right between the cylinders of the engine and the line shaft. He was dead and had evidently been scalded to death. The engineer was alive, but died in the hospital five hours later.

FIG. 3. FRAGMENTS OF EXPLODED FLYWHEEL AND PIECES OF PIPING

Just what occurred at the time of the accident is not known. From conversation with the officials and men about the plant, it appears that the oiler who fortunately escaped had, in the performance of his duties, just felt of the low-pressure crank of the wrecked engine, which was between the other two units, and had gone toward a side door. Everything about the engine room appeared to be as usual and no trouble had been experienced during the run. The first indication of danger was a crash. It is assumed that the engineer attempted to shut down the wrecked engine, as he was last seen at the throttle which was later found closed. The engine ran condensing and had 22 and 38 by 48-in. cylinders. It was equipped with an automatic safety stop and whether it or the engineer closed the throttle is not known. There is no evidence to show that the engine speeded up prior to the accident, and so far as could be determined from an examination, the governor, which was of the shaft type, was in good order.

Although the flywheel was broken into very small pieces, Fig. 3, it is not evident that it failed first. It will be noted that the sheave wheel on the line shaft was also demolished while the one on the shaft in front of it was but slightly damaged. This fact would indicate, as a probable cause for the accident, that the driven wheel failed first with the possibility, and even probability that the entangled ropes on the engine flywheel caused an initial fracture of the rim or spokes, resulting in a flywheel explosion from centrifugal force, although running at normal speed.

Most of the damage to the engine room was confined to the wrecked engine, the walls in line with the flywheel and to the roof above. But four pieces of the flywheel found after the accident were of large size. Two pieces were hurled through a 10-in. brick wall, over a store house, landing in a field. Each was about 30 in. long. Another large section, approximately 6 ft. long, passed through the roof, and landed on a spur track, severing a rail as if it had been a piece of chalk. The rest of the wheel was found scattered about the premises in very small pieces.

The flywheel was insured by the Hartford Steam Boiler Inspection & Insurance Co., which will stand the loss occasioned by the accident.

❖

National Electric Light Convention

The thirty-sixth convention of the National Electric Light Association was held in El Medinah Temple, Chicago, on June 2 to 6, inclusive. About 2000 delegates and guests were registered. President Frank M. Tait called the first general session to order at 10:30 a.m., Tuesday, and introduced the Hon. Lawrence E. McGann who welcomed the visitors to the city on behalf of Mayor Harrison, who was unable to be present.

President Tait then delivered his address, which had to do principally with association matters and the problems incident to conducting the affairs of this great organization which has grown in membership from 1300, five years ago, to over 12,000 at the present time.

The class "A" or company memberships to the association decreased from 1136 last year to 1093 because not enough new members were secured to offset the 118 resignations received due to the consolidation of many properties. A large number of papers, committee reports, lectures and addresses on subjects of importance to public light and power people were presented during the 19 general and sectional sessions of the convention. Many of these are offered in brief abstract herewith; others of more general interest will be given fuller treatment in later issues.

METER COMMITTEE REPORT

This consisted of a 47-page pamphlet reviewing the past year's work of the committee. A standard dial-face for watt-hour meters is recommended. The effect of using induction watt-hour meters on frequencies other than those for which they were designed has been studied by the committee. As a result, it is pointed out that when changing a system from a high to a lower standard frequency, the meters should be changed first and vice versa, thus safeguarding the potential circuits against undue heating or burnouts.

Another subject studied was that of metering rapidly fluctuating loads. A feeling exists that in such cases the meter fails to register all the current used. Although unable actually to conduct tests, the committee, because of information gathered, stated that there appears to be no error with the commutator type of meter. On the other hand, with the induction type, it is claimed that there is a slight tendency to register a small amount of energy in excess of that actually used—so small, however, as to be practically negligible as the error falls well within 1½ per cent., except in extreme cases.

The report also contained recommendations to use more uniform connection diagrams for instrument transformers and descriptions of the latest meter developments.

With the report was submitted the third edition of the "Code for Electricity Meters," containing nine sections, devoted to definitions, standards and measuring instruments, metering, specifications, installation methods, tests and maintenance methods.

GROUNDING SECONDARIES

After working six years the committee on grounding secondaries has secured a unanimous agreement to the desirability of grounding secondary circuits and has succeeded in having the National Electrical Code revised so that a rule now requires the grounding of such circuits having a potential of 150 volts or less. The committee recommends as the best ground a solid connection to underground metallic piping systems, making these connections where they can be periodically inspected.

LAMP REPORT

The lamp committee reported that conditions indicate the rapid substitution of the metallized and mazda lamps for the carbon. A rapid improvement in the quality of the tungsten-filament lamps and a constantly downward tendency in their price have been features of the past year. The trade name "mazda" has now been generally adopted by American manufacturers for this type of lamp.

PROGRESS IN LAMP MAKING

J. E. Randall and Evan J. Edwards presented a paper dealing specifically with the recent progress made in the art of incandescent lamp manufacture. The rated specific consumption of regular lamps has been reduced by about 0.15 watt per candlepower on the larger lamps through the careful use of chemicals which retard the blackening of the bulb. Such improvements have made it practicable to employ smaller bulbs for a given wattage.

In discussion of this paper John W. Howell brought out the point that the present 60- and 100-watt lamps give double the life at the efficiency of a year ago, and that the 10-watt standard-voltage lamp is five times as good as a year ago.

MEASUREMENTS AND VALUES

The report of the committee on the above subject discussed, without making any specific recommendations, the recent efforts of various engineering societies to unify and simplify standards, units and the terminology of power. Particular reference was made to the proposal to abandon the term "boiler horsepower" and adopt "myriawatt." In the ensuing discussion, Dr. Steinmetz, in a semi-humorous vein, deprecated the addition of new units of a more or less unscientific nature to existing terminology.

INCANDESCENT LAMPS AND LIGHTING SERVICE

In a paper under this head M. D. Cooper and Robert C. Campbell pointed out the need of greater care in laying out wiring for lighting installations as, with abnormal voltage drop, rated efficiency is not secured.

HYDRO-ELECTRIC SESSION

"The Failure of Conservation to Conserve," a paper by E. H. Thomas, Seattle, presented at the first hydro-electric and transmission session, Wednesday morning, arraigned the conservation policies sponsored by Mr. Pinchot and ridiculed the idea of a trust controlling the water-power field.

WATER-POWER PROGRESS

Following this paper the report of the committee on progress was presented by Secretary Martin in which various decisions and utterances of public authorities in regard to water-power matters were quoted and the more important features of improvement in hydro-electric engineering were reviewed. A phase of the latter portion of the report which brought out some discussion was that quoting the recommendations of official Swedish engineers of the direct-current method of transmission for a 200-mile line between Trolhatten Falls and Copenhagen, Denmark, with a potential of 90,000 volts. The consensus of opinion of those who discussed this proposition was that while direct current may offer advantages in this special case in a large majority of cases alternating-current is preferable for long-distance work, principally because of the practical limitation with the direct-current system, due to commutation difficulties, to machines of not more than 1500-kw. rating.

REPORT ON WATER TURBINES

The report of the subcommittee on prime movers pointed out that the newly developed Kingsbury thrust bearing, described in "Power" for May 13, and a new form of combined oil-presure and roller-thrust bearing together with recent advances in the design of water-wheel runners tend to improve the service of the vertical turbine. The subject of runner material was considered to some extent but left open to further discussion. Further investigation was recommended on the subject of steam-flow measurement and wheel consumption and, incidentally, a paper, to be abstracted in a later issue of "Power," by C. M. Allen, of Worcester Polytechnic Institute was presented on "Efficiency Tests of Water Wheels after Installation."

CENTRAL-STATION POWER IN COAL MINES

In a paper under this title W. A Thomas contended that in spite of the low fuel cost in an isolated power plant of a coal mine, the substitution of central-station current can be made with profit to both mine operator and central station. The reason claimed for this is that the cost of carrying the isolated plant investment over the light-load periods makes the privately manufactured current more expensive than purchased power. In addition it is claimed that the central station can profitably sell current for mine service at a low price because the load is mostly an off-peak one, hence, investment expense is small.

SWITCHING APPARATUS FOR RURAL INSTALLATIONS

This paper, by E. B. Merriam, describes semi-portable and portable substations for supplying power from existing high-voltage transmission lines and consisting of inexpensive but reliable outdoor fuses, switches, transformers, switch houses and other required devices. The development of such apparatus opens, a wide field for the sale and application of current to villages and small towns, mines, quarries, farms, irrigation and drainage work and the like.

ELECTRIC SERVICE FOR SMALL TOWNS

A paper by J. Edward Kearns suggests that by consolidating a number of small light and power systems and distributing the current from one central station instead of a number, many advantages are often secured and formerly unprofitable systems often may be put on a well paying basis. In addition, with such consolidation, it is frequently possible to serve certain classes of customers whom the small independent plant cannot afford to serve. The paper contains suggestions as to estimated costs both of construction and operation.

REPORT ON PRIME MOVERS

At the Thursday morning technical session the report of the committee on prime movers was presented by Chairman I. E. Moultrop. The report called attention to the progress being made in steam-turbine design in the direction of larger capacities and improved efficiency. A highly efficient horizontal type of Curtis machine for speeds of from 1200 to 1800 r.p.m. has been developed and several of 20,000-kw. capacity, each, are on order, while the designs of even larger units have been completed.

A so called cross-compound type of Parsons turbine has been evolved, consisting of two separate sections, as far as the steam and electrical ends are concerned. The high-pressure end operates, for instance, at 1800 r.p.m. and develops 15,000 kw., while the low-pressure section, receiving the exhaust from the high after the moisture due to expansion has been removed, operates at 720 r.p.m. and develops an additional 15,000 kw. Both sections are under the control of the governor and the high-pressure admission valves. It is said that the result of this design is a greater thermal efficiency, based on the output at the generator terminals, than with any other arrangement.

It is said that noncondensing turbines continue to grow in favor for certain classes of work and the use of the small turbine for driving station auxiliaries—exciters, feed and other pumps and blowers—is constantly spreading.

Favorable mention is made of Dr. Ferranti's turbine in which the steam is maintained in a perfectly gaseous state during its entire travel through the machine by the use of high initial superheat and reheating between first and second stages. It is reported that the steam consumption of this machine will fall below 6 lb. per steam brake-horsepower-hour.

The opinion expressed in the report of a year ago in reference to high-efficiency and self-contained units like the Stumpf, Wolf, Lentz, Locomobile and Memming engines is reiterated and the committee states that such types do not appear to be adaptable to American conditions.

The condenser design prevailing in some directions requires modification, in the opinion of the committee, because of the high degree of vacuum desired in turbine work. Passages of ample cross-section are required so that the steam may have immediate and free access to all portions of the cooling surface at moderate velocities and without following a constricted and tortuous path around baffles and between tubes.

The report further contained reference to numerous new devices and steam-plant practices which have been illustrated and discussed in "Power" from time to time.

Nothing new in the gas-power field was reported but considerable space was devoted to oil engines and statistics on the general oil supply. An important rise in the price of oil is noted and a slight falling off in production in some sections is pointed out. Faith in the heavy-oil engine continues to grow and strengthen and the number of manufacturers engaged in its development continues to increase, several additional large concerns having recently entered the field.

ELECTRICAL APPARATUS

Following this report, L. L. Elden presented the report of the committee on electrical apparatus—a 48-page pamphlet dealing comprehensively with the latest developments in generators, exciters, motor-converters, transformers, regulating apparatus, etc. High-voltage generators of large capacity to operate without auto-transformers are now available and 25,000-kw. units have become standard. Feeder regulators are increasing in efficiency and out-door regulation is a new development. New types of reverse-current relays are being brought out and increased life is being secured of rectifier tubes, principally through the use of double equipments, insuring continuity of service. Current-limiting reactances, speed of rotative apparatus, direct-coupled exciters, the use, care and life of various types of brushes and the application of motor-converters were among other topics treated. A technical discussion is also contained on the merits of several arrangements of central-station testing apparatus.

In the ensuing discussion it was stated that the new 30,000-kw. turbine set of the Commonwealth Edison Co. will deliver current at 9000 volts without an auto-transformer equipment, thus increasing the efficiency by 0.6 per cent. Noise caused by the operation of substation machinery was discussed and it was asserted that there was room for the manufacturers to effect improvement in this direction. The subject of reactances was also discussed with especial reference to the use of such apparatus for bus section and interstation service.

OVERHEAD LINE CONSTRUCTION

The joint report of committees representing five large engineering societies, on overhead line construction, contained full specification for overhead crossings of light and power lines and signaling circuits involving protection against potentials of 5000 volts or more. Reliable data are also included in regard to sags, factors of safety in line construction, conductors, insulators, poles, foundations, galvanizing, properties of wire, etc.

SWITCHBOARD INSTRUMENTS

A paper under this title by Paul MacGahn outlined the desirable features of switchboard instruments and emphasized the economy in space made possible by the use of induction types of apparatus. In addition, the freedom of such types from the influences of stray fields was pointed out.

E. G. Reed presented a paper on "The Latest Developments in Distributing Transformers," in which better winding and coil insulation were mentioned as being factors. The chief improvements, however, result from the use of guttered winding with the machine type of coil, improved machine-formed insulating barriers and the arrangement of oil-circulating ducts. Lower iron and copper losses have been secured and at the same time the insulation is better.

An interesting paper by Angus S. Hibbard on "Telephonic Communication, the Means of Control of Central Stations" was next presented. This described the elaborate use of telephone service in load dispatching as employed by the New York Edison Co.

In a paper entitled "The Central Station's Greatest Opportunity—the Electric Vehicle," E. E. Witherby emphasized the desirability of the electric-vehicle load from a central-station point of view and urged that central-station people do all within their power to foster the use of this type of automobile.

The report of the committee on electricity in rural districts was a voluminous and well illustrated work. In general, it indicated that relatively little has been accomplished in the way of profitably developing truly rural business.

In a paper on "Poles and Pole Preservation," R. A. Griffin pointed out the necessity for greater attention to the question of a preservative treatment of poles in permanent lines and reported some actual results thus far obtained.

DEVELOPMENTS IN PROTECTIVE APPARATUS

This is the title of a paper presented by J. W. Mahoney describing improvements in oil and carbon circuit-breakers and lightning arresters due to the high voltages and generating capacities now in general use. A large number of types and sizes are provided to meet various breaking-capacity requirements at voltages up to 165,000 and conducting capacities up to 4000 amperes. Design and constructional improvements for moderate capacity and voltage service include porcelain insulating pillars, clamped in position, contact details clamped thereto, use of removable separate arcing contacts, heavy steel-plate tanks with lap-welded joints, greater volume and head of oil, and strong tank-supporting details. Medium voltage and capacity breakers have, in addition, individual tanks per pole, on either a single multiple frame or individual frames for each pole, "butt" type high contact pressure laminated brush contacts self-cleaning, "butt" type solid arcing tip situated to reduce the arcing to a minimum. High-capacity, medium-voltage breakers have elliptical or round tanks, in which the metal is used in tension, of the strongest construction. Expansion chambers and appropriate vents are provided for the arc gases in all designs. For very high capacity and voltage a breaker having self-contained reactance cut into circuit on operation of the breaker is now standard.

Carbon breakers are now made in standard capacities from 3 to 24,000 amperes and up to 1500 volts direct current. Modern types include the "butt" wiping form of laminated brush with metal secondary contacts and "butt" and wiping carbon final contacts. A new feature in a line of breakers for moderate conducting and breaking capacity is the use of pressed-metal parts nearly throughout. The heavy-service breakers, for the higher currents and voltages, have several steps of increasing resistance in shunt to the main contacts, are provided with ventilating passages between the several brush units, which also reduces the skin effect on alternating current, and use the laminated or "busbar form of terminal stud. The aluminum electrolytic arrester has displaced all others for severe service. Daily charging is the usual practice and the so called "charging resistance" is used quite generally where the surges due to charging might cause trouble. An inorganic electrolyte and the annular form of tray have demonstrated their effectiveness.

STREET LIGHTING

The report of the committee on this subject is divided into three main sections: (1) Brief review of the history of street-lighting specifications. (2) Discussion of various proposed methods of measuring illuminating power of street lamps. (3) Recommendations on drawing contracts for street lighting. In many instances, contract clauses which, when accepted, were fair to all parties concerned and would have fulfilled all terms of the contract under previously existing conditions, have proven unsatisfactory due to the introduction of new illuminants and new conditions. To avoid controversy in the future certain definite principles of contract form are suggested.

RECENT DEVELOPMENTS IN FLAME ARC LAMPS

A paper on this subject discussed flame carbon arc lamp design from the standpoint of the operating and central-station man. Attention was also given to indicating how friction may be largely eliminated in the regulation of such lamps and some requirements of good operation were noted with an explanation of the manner in which these requirements may be met.

COPPER-CLAD WIRE FOR SERIES ARC LIGHTING

In a paper dealing with this topic, T. K. Stevenson pointed out the advantages of copper-clad steel wire for overhead circuits. This wire, in contrast with other types, has the advantages of being practically non-stretching and having a small coefficient of expansion.

UNDERGROUND CONSTRUCTION

The committee report on this subject this year dealt exclusively with high-tension cables and discussed periodic testing, carrying capacity, graded insulation, sector conductors, current-limiting reactances, protection of cables in manholes, parallel routes, trouble reports, practical hints as to operation and specifications for paper- and rubber-insulated cables for underground operating pressures in excess of 2000 volts. Considerable space was given to carrying capacity, and recommendation is made of a very decided increase in rating during the winter; also that the current rating be varied inversely with the voltage, on account of the heating in the insulation due to the leakage of current. The report intimated that in paper cable American manufacturers are in some respects behind European, as evidenced, for example, by the bending test. In European cables the bending test is applied three times. American manufacturers consider as too severe, a test of bending first in one direction and then in the other, twice repeated, to a radius of six times the cable diameter. The specification presented in the report increases the radius of bending to 7½ times the cable diameter.

DISTRIBUTING LINES

In the committee report on the above, voltage is not considered as a limiting factor. Voltages which a short time ago were not considered commercial possibilities are today being used not only on long transmission lines but very generally for distributing purposes. Star and delta connections, alternating and direct current, the use of batteries and of the turbine for both reserve and regulating purposes, are all given attention in connection with the problem as a whole.

A satisfactory way of carrying two circuits on the same line of poles is given. The use of iron wire is suggested where load is small and voltage regulation not of great importance, as in reclammation and irrigation work.

The rather severe requirements of the California Commission with regard to crossing construction are discussed. The relation of gross revenue to cost of investments in new line extensions is studied in its connection with long-time contracts with customers. Sometimes the extension might be made on the basis of gross revenue for five or an even greater number of years equaling the investment. The percentage of power bills rebated averages from 20 to 25.

TRANSMISSION-LINE CONSTRUCTION

The paper on this subject presented by R. C. Coombs relates primarily to transmission lines carrying voltages above the 2300-volt class. In general the construction or structural features are considered rather than the electrical or operating conditions. The author considers the physical characteristics of a pole or tower line as deserving of careful attention and believes that a too hasty inclusion of mechanical limitations in a specification may result either in disproportionate expense to the industry or in transmission lines of inadequate strength.

OPERATION OF WATER-POWER SYSTEMS

In the Committee report on this subject it was stated that the rapid increase in hydro-electric development in recent years and the growing importance of this power service is setting new operating standards. It is now fully realized that the success of such developments can be obtained only by giving a most reliable and uninterrupted service and the safeguarding of the different parts comprising the system, therefore, becomes of the greatest importance.

The efficiency and reliability of operating forces is without question one of the greatest assurances for a satisfactory operation, and it is also intimately connected with the means which are provided for communication.

The general layout of the system is naturally also an important factor. This refers to the capacities of the different generating stations, to the water conditions, to the characteristics of the load, etc. Practically no hydro-electric development with the capacity of installed apparatus above the rating at minimum stream flow is nowadays attempted with-

out a steam station on the system. Such a steam station may be used as an auxiliary station at periods of low water, as a reserve in case of interruptions, or as a regulating station to take care of the variations in the load with the hydro-electric plant running at constant output.

Consideration must also be given to the causes of disturbances and means for minimizing their effects. These are abnormal or so called emergency conditions, and in treating of them, the failure of every piece of apparatus and part of the system must be considered as a possibility and a definite plan worked out for limiting the magnitude and area of such disturbances.

TRANSFORMERS FOR POWER TRANSMISSION

This is the title of a paper by Harold H. Rudd. The great tendency at the present time toward centralization of power is making many interesting problems on power distribution. The voltage chosen for distribution must be high enough for economical transmission and not so high that the cost of a complete substation installation makes it impractical to install those of small and moderate capacity.

The development of the outdoor transformer with the necessary switching and protective devices has made it possible to use installations of small capacity at a high voltage and at very moderate cost.

The paper gives a curve of costs for installations of different capacity for various voltages. It shows that where the transmission lines feed a number of small communities, the economical voltage is 22,000 or 33,000. The saving by the use of an extremely small size transformer is so slight in comparison with the total cost of installation as to be negligible.

There is a wide variance in characteristics demanded by the different power stations, more particularly as regards voltage variation and taps. Great extensions are being made in the use of all transformers, hence, there is a need of standardization as regards taps. Such standardization will result in much good to the industry at large, to the manufacturer, and the customer.

RAILWAY LOADS FOR CENTRAL STATIONS

The last technical paper presented at the convention was by E. P. Dillon on "Electric Railway Loads on Central Stations." Attention was called to the desirability of railways, both city and interurban, as power customers for central stations. In some of the larger cities the problem has been very thoroughly worked out and excellent results obtained by combining the requirements of the two classes of service on one generating system.

ELECTION OF OFFICERS

By constitutional amendment provision was made for two additional vice-presidents. The election of officers resulted as follows: President, J. B. McCall, Philadelphia, Penn.; first vice-president, John A. Britton, San Francisco, Calif.; second vice-president, H. H. Scott, New York City; third vice-president, E. W. Lloyd, Chicago, Ill.; fourth vice-president, E. C. Deal, Augusta, Ga.; treasurer, W. F. Wells, Brooklyn. The secretary is appointed by the executive committee.

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A liquid rheostat for large alternating-current motors has recently been developed by the Westinghouse Electric & Manufacturing Co., to supply the demand brought by the use of large slip-ring motors driving mine hoists, winding gears, rolling mills, etc. Such a rheostat provides an infinite number of speed steps between limits and permits smooth acceleration. This particular design comprises two compartments, an upper tank for immersing the electrodes and a lower storage reservoir. The small motor-driven pump maintains a steady stream of liquid, usually an alkaline solution, from the lower reservoir into the upper tank, the latter discharging its contents back into the former over a weir, which takes the form of a tube that can be raised or lowered through the floor of the electrode tank. By raising or lowering the weir the height of liquid in the electrode tank is varied and resistance between electrodes changed as desired. The operating lever of the rheostat controls both the weir and a master switch, which opens and closes the primary circuit of the motor. A valve in the intake pipe of the electrode tanks regulates the rate at which the liquid can be pumped in, so that no matter how quickly the operating arm is thrown over the liquid can rise in the tank only at a definite rate, thus fixing the rate of acceleration. Cooling coils for circulation of water are introduced in the lower reservoir to prevent overheating and rapid evaporation. The capacities so far designed are from 400 to 1500 hp. of controlled motor.

New York State N. A. S. E. Convention

The 18th annual convention of the New York State Association of the National Association of Stationary Engineers was held at Yonkers on June 12, 13 and 14, in the Armory.

On Thursday, June 12, the exhibition hall was opened to the public with appropriate speeches and was well attended.

The regular business meeting was held on Friday morning, Chairman Louis Bernard presiding. The Hon. James T. Lennon, mayor of Yonkers, welcomed the delegates, National Vice-President James R. Coe responding. Other addresses were made by the Hon. Nathan A. Warren, president of the Chamber of Commerce; State President George O. Kaley, Past National President William J. Reynolds, Past National President Edward Kearney and ex-State Senator Louis Munzinger.

On Saturday, June 14, the usual business session was held. In the afternoon, with the Otis Elevator Co. as host, a frolic at Kinross was given the members and their guests. There were many amusements furnished and refreshments were served. The Otis company was declared to be a most hospitable host, and all returned greatly pleased with the outing.

A vaudeville entertainment was given in the exhibit hall on Friday evening, and was well patronized. Among the entertainers were Joe McKenna, of Jenkins Bros.; Jack Armour, of "Power"; Mr. Martell, of the Peerless Rubber Co.; Maybelle Burke, Frank Corbett and the Dixie Four. Frank Martin was stage manager.

The following officers were elected for the ensuing year: Past president, George O. Kaley; president, Edgar E. Pruyn; vice-president, Fred Felderman; secretary, William Roberts; treasurer, William Downs; conductor, Elmer Hartley; doorkeeper, Joseph Burback.

The convention for 1914 will be held in Buffalo.

The committee of arrangements were: Louis Bernard, chairman; Frank Connolly, William Tompkins, James T. Roberts, Thomas Sharp, David Murray, Albert Serrell, Joseph C. Ryan, Wm. Roberts, John Buckley, David Thompson, Charles Wittemore, John Lewis, Frank Reiger, Harry Wallace

THE EXHIBITORS

Albany Lubricating Co.
V. D. Anderson Co.
American Engine Co.
Armstrong Cork Co.
Ashton Valve Co.
A. B. Barr
W. M. Bastable Co.
J. H. Banks & Co.
Bayer Steam Soot-Blower Co.
F. S. Bowser Co.
Buhne Metal Packing Co.
Boig & Hill
Broderick & Bascom Rope Co.
C. T. Coe Co.
Chamber of Commerce
Chapman Valve Co.
Crandall Packing Co.
Coppus Engineering Co.
M. T. Davidson Pump Co.
Dearborn Chemical Co.
Danubil Co.
Diamond Power Specialty Co.
Eddy Valve Co.
Erie City Iron Works
Economy Fuse & Mfg. Co.
Fairbanks Co.
Felber Engineering Co.
D. W. Freeman
Garlock Packing Co.
Greene, Tweed & Co.
Griscom-Russell Co.
Greenpoint Fire Brick Co.
Grieve Grate Co.
Hewes & Phillips Iron Works
Homestead Valve Co.
Hazard Mfg. Co.
Home Rubber Co.
Harrison Safety Boiler Co.
Jenkins Bros.
H. W. Johns-Manville Co.
Keystone Lubricating Co.
Kieley & Mueller
Ladew Estate
Ladies' Auxiliary
Lagonda Mfg. Co.
Lunkenheimer Co.
William Martin
McLeod-Henry Co.
H. Mueller Mfg. Co.
McCord Mfg. Co.
W. B. McVicker Co.
Harry Marks
I. R. Nelson
"National Engineer"
N. Y. Belting & Packing Co. (Ltd.)
Otis Elevator Co.
J. O'Meara, Inc.
"Power"
Peerless Rubber Co.
Perolin Co.
F. B. Potterton
"Practical Engineer"
Pitts & Kitts Mfg. & Supply Co.
Philadelphia Grease Co.
Quaker City Rubber Co.
J. L. Quimby & Co.
Clement Restein Co.
Roebling Wire Rope Co.
J. C. Ryan
Russell, Birdsall & Ward
Skinner & Connolly
C. E. Squires Co.
L. Sonneborn Sons
"Southern Engineer"
Shipley Construction & Supply Co.
Standardizing Co.
Texas Co.
Thread Tight Co.
H. L. Twine
U. S. Graphite Co.
United Metal Hose Co.
F. W. Webb
West Disinfecting Co.
Washburn & Granger
The Waite Co.

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Ontario's New Boiler Regulations

Effective July 1, will be the regulations recently passed by the Province of Ontario, Canada, relating to the construction and inspection of boilers. To D. M. Medcalf, public inspector of boilers for the province, manufacturers of boilers to be used in the province must henceforth submit plans and specifications to show that both the material and manner of constructing accord with the prescribed standards. All new boilers must so conform and second-hand boilers to which extensive repairs have been made will also be inspected.

Smoke Inspection in Milwaukee

The annual report of Charles Poethke, smoke inspector for the city of Milwaukee, Wis., has recently been made public.

The following details part of the work done by that department for 1912: Smoke charts taken, 82; photographs taken, 400; written warnings, 96; letters written, 236; letters received, 245; complaints received, 59; cases dismissed on technical error, 0; cases dismissed (not guilty), 0; sentences suspended on payment of cost, 14; cases in court fined $25 and costs, 41; cases in court fined $50 and costs, 5; cases in court, second offense in 1912, 6; total number in court, 60; total fines imposed, $1275. The maximum minutes of dense smoke recorded where legal action was brought was 35 min. in one hour; the minimum 11½ min.

There were 1452 observations of chimneys and stacks made and recorded as follows: January, 15; February, 30; March, 75; April, 83; May, 100; June, 152; July, 129; August, 191; September, 134; October, 149; November, 201; December, 193. Forty permits were issued for remodeling and new installations of furnaces.

Of the offenders there were 22 manufacturers, six coal companies (yards), three woodworking plants, one brewery, three electric-light companies, one store, one department house, one laundry, two tanneries, three office buildings, four boat lines, one tug-boat company, one dredge and pile-driving company, one grain elevator, four flour mills, two asphalt plants.

The Chicago, Milwaukee & St. Paul R.R. employs two smoke inspectors, and the Chicago, Northwestern Ry. one, each paid by its company. Their duty is to instruct firemen how to fire with least possible smoke. If found negligent in keeping down dense smoke, whether they violate the city ordinance or not, the firemen are either reprimanded or suspended for from five to thirty days without pay or discharged. The railroad inspectors report on their work to the city smoke department twice a week, and also to receive complaints or any other information.

"To increase the efficiency of the department," states the inspector, "a motor boat should patrol the three rivers, as this is the only effective method of obtaining evidence on account of the moving boats. At present these violations can only be obtained when boats are docked, and while being tied up they, as a rule, avoid excessive smoke.

"A small automobile is also necessary to cover the city and especially to have control of the one-mile zone which covers an additional area of 17 square miles. Smoke, soot and cinders are deposited during the night and can be found on the walks in the morning. This is a nuisance; the only way of relief is by an automobile. The same should be equipped with a searchlight which can be directed upon chimneys and stacks under suspicion of committing these nuisances after dark. A few such cases brought before justice would undoubtedly find a discontinuance in a short time."

The department consists of the smoke inspector, two deputies and one clerk-photographer.

PERSONALS

George H. Burke, for several years manager of the New York office of the Sarco Engineering Co., will open an office in Chicago, July 1, to take care of the firm's business in the Middle West.

M. Plunkett, master mechanic of the Choctaw Railway & Lighting Co., McAlester, Okla., has had his jurisdiction extended over the maintenance of equipment and the power station, succeeding N. E. Daniels, chief engineer of the power station.

SOCIETY NOTES

The date for the Michigan State N. A. S. E. convention at Grand Rapids has been changed from June 18, 19 and 20 to Aug. 6, 7 and 8.

On June 10, 114 young men received the degrees of Lehigh University in technology and in arts and sciences at commencement exercises held in Packer Memorial Church. President Henry Sturgis Drinker conferred 36 degrees in civil engineering, 17 in mechanical engineering, 17 in mining engineering, nine in electrical engineering, eight in electrometallurgy and metallurgy, five in chemistry and chemical engineering, three of bachelor of arts, and seven of bachelor of science. The last includes the first graduates in Lehigh's new course in business administration. Nine degrees of master of science were conferred and three of master of arts.

NEW PUBLICATIONS

ENGINEERING THERMODYNAMICS. By C. E. Lucke, professor of mechanical engineering at Columbia University. Published by McGraw-Hill Book Co., New York. Size, 6x9 in.; 1176 pages, illustrated, cloth. Price, $8.

This book is probably the most extensive work ever published on the subject of engineering thermodynamics. It is difficult, however, to determine which class of readers it is intended to serve. As a textbook for undergraduate college courses in thermodynamics, it is hardly suitable on account of its bulk, but it should prove useful as a supplementary text for graduate students in mechanical engineering. It contains 143 very complete tables and numerous diagrams, charts and equations. An alphabetical index to the tables and charts would be an improvement.

The subject matter of the book is treated in three parts. The first deals with work without consideration of heat changes; the second takes up the heat and the third part is devoted to the relation between heat and work. The elementary principles of physics as applied to work and power are explained, more space being given to the solution of simple problems than would prove of value to one taking up the study of thermodynamics. The part dealing with the dynamics of nozzles and jets is very practical.

The determination of the work done in compressor cylinders is then considered, and formulas are derived for the single-stage, two-stage and three-stage compressors, for cycles with isothermal compression, and for exponential compression, with and without clearance. The author might have saved space and avoided repetition of the formulas by working out only the most important cycles, and leaving the other cases as problems to be solved by the student. Charts for the graphical solution of compressor problems are included.

The work available in engine cylinders is taken up at great length, and the action of fluids in single- and multi-expansion engines is clearly illustrated by numerous problems. The engine cycles analyzed in this part include those with logarithmic and exponential expansions with and without clearance for simple engines, compound engines with finite receiver, compound engines with infinite receiver, compound engines without receiver, and triple-expansion engines. The part devoted to the general case of multiple-expansion and to consumption of steam engines is well presented.

Under the heading "Heat and Matter," will be found a great deal of valuable data and uptodate information. The part dealing with the properties of ammonia is especially good. Other items treated very fully are specific heats of gases and vapors, properties of vapors and combustion. Too much space seems to be given to the fundamentals of thermometry. Also the properties of gases and vapors might have been treated independently of each other to avoid confusion.

In connection with the thermal processes a very exhaustive study is made of the properties of solid, liquid and gaseous fuels, and of their comparative heat values. The gasification of fuels is treated clearly and at great length, this including gasification of solid fuels by air-blast alone, by steam blast alone, and by a combination of steam and air blast reactions, producing air gas, water gas and producer gas respectively. The burning of fuels with draft under boilers, evaporation and heat balance in steam generators are taken up in detail. This part of the book includes the results of the most recent experiments on the gasification of fuels.

The last part deals with the relations between heat and work. Much space is given to the methods of plotting entropy diagrams, and to the comparison of steam and gas cycles, plotted between entropy-temperature and pressure-volume coördinates. The thermal efficiency and performance of various heat engines are compared. The part dealing with the flow of vapors and gases is good. The subject of mechanical refrigeration includes excellent charts and diagrams, but is treated rather too briefly.

The book contains an immense amount of valuable uptodate information presented in a very original manner. The arrangement of the subject matter might have been improved, however, if the parts dealing with the work in compressors and engine cylinders were placed after the chapters dealing with heat, or still better if abbreviated and treated in connection with that part which takes up the relation between heat and work.

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared by Sterrett & Brunner, 156 State St., Boston, Mass., for the construction of a power plant to generate 2000-hp. to be erected on the new fish pier at South Boston. William J. O'Brien is interested.

The town council of Blairsville, Penn., is considering plans for the construction of an electric-light plant.

Plans are being considered by the Philadelphia Rapid Transit Co. for the construction of a power plant at 13th and Mifflin Sts., Philadelphia, Penn. Estimated cost, $30,000. W. L. Maize is purchasing agent.

SOUTHERN STATES

The city of High Point, N. C., contemplates the installation of additional equipment for its electric-light system. H. C. Bulla is manager.

The Southern Power Co. is considering plans for the construction of a substation at Rock Hill, S. C. W. R. Connell, Charlotte, N. C., is purchasing agent.

The improvement of the municipal electric-light plant and water system at Bastrop, La., is under consideration. J. K. Skipworth is mayor.

CENTRAL STATES

The managers of the electric-light board of Anna, Ohio, are considering plans for the installation of additional equipment in the municipal electric-light plant. T. S. Price is clerk of the board.

If granted a new franchise the Cleveland, Southwestern & Columbus Ry. Co. will expend $20,000 for the improvement of its power plant at Norwalk, Ohio. C. G. Taylor is superintendent.

The proposition to issue $20,000 in bonds for the improvement and installation of new equipment in the municipal electric-light plant at Bluffton, Ind., is under consideration.

The Grand Rapids-Muskegon Power Co. contemplates the construction of a substation at Wealthy St. and Indiana Ave., Grand Rapids, Mich. Estimated cost, $18,000. A. F. Walker is superintendent.

The American Car & Foundry Co. will build a one-story power plant in connection with its establishment at South Wood and Paulina Sts., Chicago, Ill. Estimated cost, $5400.

The village board, Manito, Ill., is considering plans for the construction of an electric-light plant.

BUSINESS ITEMS

Orenstein-Arthur Koppel Co. has given the agency for its Canadian business to the Canadian Fairbanks-Morse Co., Ltd.

John U. Higinbotham is now assistant treasurer of the Detroit Lubricator Co., Detroit, Mich.

TRADE CATALOGS

J. Faessler Mfg. Co., Moberly, Mo. Catalog No. 32. Boilermakers' tools. Illustrated, 40 pages, 6x9 in.

Falls Machine Co., Shebofgan Falls, Wis. Pamphlet. Automatic engine stop. Illustrated, 24 pages, 5x8 in.

American Engine Co., Bound Brook, N. J. Pamphlet. "A New Paper Mill Engine." Illustrated, 16 pages, 6x9 in.

The Weber Chimney Co., McCormick Building, Chicago, Ill. Catalog. Reinforced-concrete chimneys. Illustrated, 48 pages, 5x9 in.

The Climax Smoke Preventer Co., Equitable Building, Boston, Mass.—Catalog. Smoke preventer. Illustrated, 20 pages, 6x9 in.

The Heine Chimney Co., 72 West Adams St., Chicago, Ill. Catalog. Interlocking radial brick chimneys. Illustrated, 32 pages, 4x9 in.

Harrison Safety Boiler Works, Philadelphia, Penn. Booklet. Evolution of the Cochrane Multiport Valve. Illustrated, 52 pages, 3x6 in.

John F. Swan, 10th St. and Duncannon Ave., Philadelphia, Penn. Pamphlet. Hawley down draft smokeless furnace. Illustrated, 5x8 in.

Clayton Air Compressor Works, 115 Broadway, New York. Bulletin No. C-210-S, printed in Spanish. Air Compressors. Illustrated, 32 pages, 6x9 in.

The Blake & Knowles Steam Pump Works, 115 Broadway, New York. Catalog B-K 876. Single direct-acting pumps. Illustrated, 84 pages, 6x9 inches.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 128. Miscellaneous equipment for pneumatic drills. Illustrated, 12 pages, 6x9 in. Bulletin No. 132. Pneumatic motors and pneumatic geared hoists. Illustrated, 20 pages, 6x9 in. Bulletin No. 133. Cylinder air hoists and jacks. Illustrated, 12 pages, 6x9 in.

The Bristol Co., Waterbury, Conn. Bulletin No. 132. Recording differential pressure gauges and recording flow-rate meters. Illustrated, 16 pages, 8x10¼ in. Bulletin No. 170. Patent electric furnaces for soldering coppers. Illustrated, 2 pages, 8x10½ in. Catalog No. 1300. Class III recording thermometers. Illustrated, 48 pages, 8x10½ in.

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ELECTRICIAN, 23; steady position power plant or contracting concern; eight years' practical experience wireman and maintainer; will go out of town. P. W. 920, Power.

CHIEF ENGINEER, age 32, holding responsible position, desires change; first-class Ohio license; married; strictly sober; South or Central States preferred. P. W. 919, Power.

A TECHNICAL MAN wants position as superintendent of an electric-lighting and refrigerating plant; age 34; good reasons for changing. P. W. 915, Power.

A MECHANICAL ENGINEERING GRADUATE wants position as superintendent of power, or master mechanic with a manufacturing firm; 11 years' varied experience; now employed. P. W. 914, Power.

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MANUFACTURERS REPRESENTATIVE, favorably known and of wide experience in modern engineering, wishes to handle power-plant equipment, engines, boilers, stokers, etc., in Pittsburgh district. Daniel Ashworth, M. E., 1225 Fulton Bldg., Pittsburgh, Penn.

FOR SALE

20x42 HUGHES & PHILLIPS tangye frame Corliss engine; cost $4000; like new; $1200. Duzets & Son, Hudson Terminal, New York.

20x42 LANE & BODLEY HEAVY DUTY CORLISS ENGINE; condition like new; $900. Eastern Machinery Exchange, 171 Broadway, New York.

ONE 150-HP. FISHKILL CORLISS ENGINE and flywheel; one 150-hp. return-tube boiler; one 7½x8½x12-in. Deane steam fire pump; all in very good condition. Apply Barnet Leather Co., Little Falls, N. Y.

GAS ENGINE, 225 hp. American Crossley horizontal double cylinder, opposed 22x30 in., with Akerlund producer; located Columbia, S. C.; selling account cheap hydro-electric power; bargain. P. S. 904, Power.

THE FOLLOWING DIRECT CONNECTED UNITS: 20KW, 125 Volts; 40KW, 125 Volts; 100 KW, 250 Volts; 150KW, 250 Volts; 200KW, 250 Volts. Corliss Engines: 12x26, 14x36, 16x42, 22&38x48, 26&54x60, 30&60x60 Hamilton. Send for complete list of Engines, Boilers, Generators, Motors. Harold R. Wilson Machinery Co., St. Louis.

GAS ENGINE—One Foos vertical 15x20-in. three-cylinder producer-gas engine, 150 brake hp., speed 225 r.p.m., connected to S-5½-E, 100 kw., 250-volt, compound-wound, direct-current Western Electric generator with field rheostat; approximate weight, 49,000 lb.; good condition; very moderate use for about two years. P. S. 917, Power.

WE HAVE FOR SALE a practically new vertical MacIntosh & Seymour engine, high-pressure cylinder, 16 in. in diameter; low-pressure cylinder, 32 in. in diameter; stroke of engine, 42 in.; revolutions per minute, 125; indicated horsepower, 660 to 980; also heater, separator and condenser; total price, $7500, f.o.b. cars, Nashua, N. H. The Jackson Co., Nashua, N. H.

MISCELLANEOUS

PATENTS SECURED—C. L. Parker, Patents 904 G St. Washington, D. C.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash-Younker Co., 1417 W. Jackson Blvd., Chicago, Ill.

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